WHITE PAPER

INDUSTRY WHITE PAPER ON SMART HOSPITALS POL (PASSIVE OPTICAL LAN) NETWORK APPLICATIONS

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Ametic
LA VOZ DE LA INDUSTRIA DIGITAL

Foreword

Digital transformation has become an urgent necessity in all sectors of society, and healthcare is no exception. In recent years, there has been a growing interest in finding innovative and efficient solutions within the healthcare field. This responds to the need not only to improve the service quality but also to optimize the resources available in the system.

Innovation, driven largely by technological advances and digitalization, has led to the development of new solutions that facilitate the delivery of more personalized and accessible health services. They aim not only to improve clinical outcomes and patient safety, but also to transform the experience of users, users of the health system, including patients, clinicians, administrative staff and other stakeholders, making it more agile... precise and focused on the real needs of all the actors in the system (patients, caregivers, health professionals, etc.). In these innovations, professionals find new ways to manage their work, allowing them to spend more time on direct care and reducing the administrative burden.

In this context, AMETIC, Spain's digital sector employer, through its Digital Health Commission, has prepared this White Paper on Applications of POL (Passive Optical LAN) Networks in Intelligent Hospitals. This report is the result of extensive research and collaboration with industry experts, technology providers, technology centers, universities and research personnel. It aims to highlight the key role of POL networks in digitising the healthcare sector.

This White Paper responds to the need to share knowledge and experience to facilitate the adoption of innovative technologies in healthcare. This report provides detailed information on the features, benefits, and examples of potential use cases of POL networks in smart hospitals, providing a practical guide and valuable reference for professionals in the industry.

The report addresses key regulatory issues, emphasizing the importance of a robust regulatory framework that enables the safe and efficient adoption of POL networks. This regulation plays a crucial role in ensuring that technologies and architectures deployed in POL networks meet security, privacy, and quality of service requirements. In addition, an appropriate regulatory framework facilitates interoperability between different systems and suppliers, promoting a technological, sustainable and competitive ecosystem.

This work reflects the commitment of AMETIC and its Digital Health Commission to promoting innovation and improving the quality of health services. We strongly believe that POL networks play a crucial role in creating smart hospitals by providing greater efficiency, security, and an improved experience for patients and professionals.

The following pages explore the latest trends in the use of POL networks and provide practical examples of their implementation. We hope that this White Paper will become an essential tool for the development and implementation of POL-based solutions in smart hospitals.

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1. Development Environment Analysis for Smart Hospital POL Networks

The development of smart hospitals represents a crucial step forward in the digitalization of the healthcare sector, driving more efficient and personalized healthcare.

Collaboration among technology players, healthcare providers, and regulators is essential to building an ecosystem that prioritizes innovation and sustainability, ensuring that all patients have access to quality care in a safe, connected environment.

1.1. What is a smart hospital?

A smart hospital is a healthcare facility that integrates advanced technologies and connectivity, both between devices and with information systems, to transform patient care and improve operational efficiency. This type of hospital is based on the convergence of digital systems, medical devices, and data management platforms, creating a collaborative, patient-centered environment. The smart hospital harnesses the potential of Information and Communication Technologies (ICT), as well as emerging technologies such as Artificial Intelligence (AI), Internet of Things (IoT) and Augmented/Virtual Reality (AR/VR), to help improve Innovate and optimize healthcare processes.

1.1.1. Key features of an intelligent hospital

- **Connected Infrastructure:** It has a robust technology infrastructure and reliable communication networks that allow real-time information to be connected and exchanged between devices, IT systems, and healthcare professionals.
- **Data Interoperability:** Ensures interoperability between different systems and platforms, facilitating a smooth and secure exchange of clinical and administrative information that improves decision-making.
- **Real-time data management:** Collects and analyzes patient data to improve diagnosis and treatment, using Big Data tools and predictive analytics.
- **Artificial Intelligence and Data Analytics:** Employs AI algorithms and advanced analytics techniques, such as machine learning and natural language processing (NLP), to extract valuable insights that optimize healthcare.
- **Automation and Robotics:** Incorporates robots and automated systems for tasks such as medication dispensing and internal logistics, freeing healthcare professionals from routine tasks and improving safety.
- **Emerging technologies:** Integrates technologies such as augmented/virtual reality (AR/VR), wearables, and assistive robots, improving the patient experience and optimizing the tasks of healthcare professionals.
- **Cybersecurity and privacy:** Given the high volume of sensitive data it handles; it implements robust cybersecurity measures to protect patient information and ensure the integrity of its systems. This includes complying with international standards and relevant regulations, ensuring the confidentiality and security of health data. The smart hospital ensures the security and privacy of health data, following international standards such as the Personal Data Protection Act and ISO 27799:2016.
- **Patient-Centered Environment:** Uses technology to improve the patient's experience through mobile apps that manage appointments and access medical information, as well as physical environments tailored to patient needs.
- **Telemedicine and remote care:** facilitate remote care through telemedicine platforms,

enabling effective interactions between healthcare professionals and patients without the need for face-to-face visits.

- **Sustainability and Energy Efficiency:** Implements smart energy solutions to optimize resource consumption and minimize environmental impact, contributing to a more sustainable approach to healthcare.

1.1.2. Benefit of the smart hospital

The smart hospital not only improves patient care, but also benefits healthcare professionals and healthcare organizations, highlighting the following benefits:

- **Better quality of care:** Integrating technology and connectivity allows for more accurate diagnosis and faster decisions.
- **Operational Efficiency:** Optimizes resource utilization, reduces waiting times, and improves overall management.
- **Patient experience:** A friendlier, more accessible environment increases satisfaction and adherence to treatment.
- **Expanded access to care:** Telemedicine and digital tools enable more patients to access quality medical services.

1.2. Market Requirements Analysis

1.2.1. National Health System Organisation (NHS)

The Spanish National Health System (SNS) is part of the so-called "Beveridge model", also present in countries such as the United Kingdom, Sweden, Norway, Denmark, Italy and Portugal, characterized by its financing through general taxes. Under this model, all citizens are entitled to health care, which defines its principles of universality and equity. Common health care is financed jointly and severally, so that all taxpayers, through their taxes, provide the necessary resources to meet the needs of those who need assistance.

As a result, the State plays a central role in regulating and managing the health system. The planning and provision of health services is primarily a public responsibility, although there is a private network acting in a complementary and sometimes concerted manner. The structure and operation of the NHS are governed by the 1986 General Health Act and the 2003 NHS Cohesion and Quality Act.

An essential element of the Spanish health system is its extensive decentralization. Responsibility for the provision and management of health care has been transferred to the 17 Autonomous Communities since 2002. The autonomous governments determine the development patterns of the respective health services and approve the final financial allocations to cover health care costs. in their annual budgets. Therefore, the SNS is the political and organizational model of Spanish health care, which is distributed in turn in the different autonomous health services as provisional entities and managers of the service portfolio.

Public health is financed indirectly through the so-called "autonomous financing model", which provides the Autonomous Communities with a substantial part of their regular resources, once collected by the General Administration of the State (AGE).

The Ministry of Health maintains overall coordination functions and establishes the common foundations of the health system. It is responsible for ensuring the cohesion, equity and quality of the NHS throughout the country, and is responsible for specific areas such as the health professions regime and pharmaceutical provision. It also promotes general health and public health strategies through the adoption of various multi-year plans.

The Interterritorial Council of the SNS (CISNS) is the main coordinating body between the State and the Autonomous Communities, where consensus on health policies is promoted, and joint decision-making takes place. The national parliament (Cortes Generales) can make laws within the current model of competence, and the regional parliaments carry out their normative function on health policy in relation to their territories and governments.

1.2.2. Functional and resource organization

As a whole, and through the various autonomous health services, the NHS is organized into two main levels of care:

- Primary Care: made up of health centers and local clinics.
- Specialized Care: consisting of hospitals and specialty centers.

Emergency services are distributed between the two levels. In addition, there are resources related to prevention and public health policies and strategies, both national and regional, and cross-cutting programmes for different high-impact pathologies. The system has specific decision support agencies and bodies, such as the Carlos III Health Institute, the Technology Assessment Agency, and the Spanish Agency for Medicines and Health Products (AEMPS).

This structure seeks to balance the autonomy of health management and provision decisions with the need to maintain a cohesive and equitable system at the national level, adapting to the particularities of each territory, while guaranteeing universal and quality access to health services throughout Spain.

1.2.3. The Health Sector in Numbers

According to data from the Ministry of Health (reported in the *NHS Annual Report 2023* , published on 5 August 2024, last available), the NHS healthcare network has 3,042 health centres and 9,998 local clinics. The NHS has a network of 449 hospitals: 310 acute hospitals and 139 medium/long stay hospitals. 81.6% of the hospital beds in operation in Spain are in the NHS network (114,671), which also has 86.8% of day hospital posts (21,000). The rest are in the privately owned healthcare network.[1]

Primary Care provides more than 256 million medical consultations and more than 156 million nursing consultations each year, of which 39.1 per cent and 13.6 per cent respectively are attended by teleconsultation. Around 3 million medical visits and 10.5 million nursing visits take place in the patient's home.

NHS hospitals see around 4 million patients admitted each year and around 87 million medical visits. 3.5 million surgeries are performed annually, and 48.6% of major surgery is done on an outpatient basis.

Urgent care accounts for an annual activity of about 32.7 million visits in primary care, about 22.8 million in hospitals and 9 million in services 112/061.

9.1% of primary care patients are seen on the day for a doctor's appointment and 12% the next day, and the rest have waited an average of 9.1 days in 2023. Similarly, the average waiting time for the first Specialist Care consultation is 87 days. The average waiting time for elective non-urgent surgery is 112 days.

A total of 763,355 professionals work in the NHS care network, 75.7% in hospitals, 16.0% in primary care centres, and 3.4% in emergency and emergency services 112/061. Medical and nursing staff account for

[1] https://www.sanidad.gob.es/estadEstudios/estadisticas/sisInfSanSNS/tablasEstadisticas/InfAnSNS.htm

51.6 per cent of the workforce. The NHS care network has a total of 172,157 medical professionals and 221,406 nursing professionals, the largest group with a nursing/medicine ratio of 1.3. Primary care has 43,815 doctors and 42,094 nurses, of whom 36,912 and 33,036 respectively. They are part of the Primary Care teams, and the rest are area professionals or work in out-of-hospital emergency departments. Hospitals in the NHS network employ the largest number of health professionals: 93,199 doctors and 171,963 nurses.

Rates of medical and nursing professionals per 1,000 population have remained virtually constant since 2012 in Primary Care teams, while staff growth has been significant in NHS hospitals and emergency and emergency services 112/061. In addition, a further 369,792 professionals work in the NHS contributing to the provision of health care, including other graduates with a health function such as non-medical health workers and non-health workers.

The private sector employs more than 300,000 health professionals (some of them reconciling activities in the public sector) of whom 69,000 are doctors, according to the Private Healthcare Observatory 2024 of the IDIS Foundation.

Public government health expenditure amounts to €94,694 million, accounting for 71.7% of total health expenditure (€131,984 million), increasing by 27.3% since 2017, according to the Ministry of Health's latest annual report. Public health expenditure accounts for 7.8% of GDP. Rehabilitation and curative care services account for the largest share of public health expenditure (57.2 per cent).

Private health expenditure accounts for 3.1 per cent of GDP. 73.0% of this is borne by direct payments from households (pharmaceuticals - including NHS prescription co-payments - therapeutic devices - glasses, hearing aids, etc. - and dental care, mainly).

According to the most recent consolidation national accounts data contained in the report of the Economic and Social Council *The Health System: Current Status and Prospects for the Future 2024* , health expenditure in Spain is lower than the average for the European Union and OECD countries. In 2021, Spain spent 10.7% of its GDP on health care (including public and private), slightly below the EU average of 11%. Per capita expenditure in Spain was €2,771, significantly lower than the EU average of €4,028.

The private hospital market in 2023 was €13.02 billion, 5.0% higher than in 2022. This continued the growth trend that over the past 20 years did not stop until 2020 after the start of the pandemic. This positive development was supported by the expansion and improvement of supply, as well as by the increased demand for private health services, in the context of increasing difficulty for public health facilities to adequately cover health care.

Despite the slowdown in economic growth, the expected increase in prices and the positive influence of demographic trends, in particular the ageing of the population and the growing demand of the foreign population, will encourage a further increase in turnover. The market is expected to grow by about 4% per annum in the biennium 2024-2025.

1.3. Technological innovation as a driving force

1.3.1. New technologies to facilitate the development of smart hospitals

The digitization of hospitals, along with the continuous development of new medical applications and technologies, has transformed hospitals into some of the facilities where the most data is generated, processed, and stored. This data is not only abundant but also extremely sensitive, which means it requires the highest levels of security and must be immediately available to health professionals who rely on it for clinical decision-making. For example, all the management and storage of digital images produced by Magnetic Resonance (MRI), Computed Tomography (CT), Proton Emission Tomography (PET) or Photon Measurement Technology (Quant are crucial in this context.

In addition to these well-known technologies, Digital Genomics is now being developed, which analyzes and interprets the entire DNA of an organism, allowing the identification of genes responsible for hereditary diseases and providing personalized treatments for complex diseases, cancer, etc. These new tools help you take preventative measures to reduce the risk of developing certain inherited diseases. This facilitates research into new therapies and drugs, allowing scientists to understand how genes interact with each other and the environment. Testing of foetuses and newborns detects genetic abnormalities and allows rapid intervention.

In addition, pharmacogenomics, a subdiscipline of genomics, has been developing in recent years to study how genes affect a person's response to drugs. This helps to personalize drug treatments and minimize side effects .

These new disciplines generate a huge amount of data, which is no longer measured in gigabytes (GB) but is now measured in terabytes (TB) and even petabytes (PB). This explosion in data volume is driven by these technological advances allow for more detailed and accurate data collection, especially in fields such as genomics, medical imaging, and clinical research. For example, sequencing an entire human genome can generate between 100 and 200 gigabytes (GB) of raw data. This volume is even greater when derivative analyses, such as the interpretation of genetic variants, are included, amplifying the need for robust infrastructures for storing, managing, and processing these huge data sets. This increase in the scale of information poses new challenges to the efficiency of IT systems and data security, especially when it comes to sensitive medical information that must be protected under strict regulations.

In addition to day-to-day operations within hospitals, including electronic medical records management, pharmaceutical inventory tracking, and other administrative tasks, we now have to add the impact of Artificial Intelligence (AI) Health Data Spaces. Internet of Things (IoT), Surgical Robotics, Connectivity with other hospitals and health centers, Security, Digital Connectivity of healthcare professionals, patients and equipment, etc. All of this data needs proper communication networks that can be handled, stored and accessed quickly and securely, with high-capacity bandwidths and minimal latencies.

In summary, the growing demand for high-speed communication networks in hospitals is driven by several key factors that go beyond simple connectivity. First, improving the quality of medical services depends on fast and accurate communication between medical devices and clinical information management systems, enabling faster decision-making with real-time data. Second, enhanced medical data processing capabilities, such as advanced medical imaging systems or AI-based analytics, require robust networks that can handle large volumes of data without delay.

Added to this is the need to improve day-to-day operational efficiency by optimizing workflow, staff coordination, and access to critical information at any time. In addition, the popularization of IoT devices in the hospital environment, such as patient monitors, smart sensors, and wearable devices, generates a constant flow of data that needs to be efficiently and securely managed. Finally, modernizing security systems, both physical and digital, requires fast and reliable networks that can support real-time surveillance, protection of sensitive data, and cybersecurity against attacks or information breaches.

1.3.2. Fiber In and Copper Out

Since Charles Kuen Kao laid the foundation for the transmission of signals through optical fibers in his studies Dielectric Fiber Surface Waveguides for Optical Frequency published in 1966, Both scientists and industry have made remarkable strides in advancing fiber communication technologies. In 2008, Spain began to deploy fiber-to-the-home (FTTH) technologies on a massive scale, becoming the most developed country in terms of FTTH in Europe today. In 2020, the European committee published the Digital Decade report and set a target of 100% fiber connectivity in homes by 2030, so the proposed Passive Optical LAN (POL) network uses FTTH technologies, typically based on Passive Optical Network (PON) technologies.

Compared with traditional copper lines, a POL network not only has high bandwidth, low latency, and high stability, but also has obvious advantages in longer distance transmission, raw material consumption, reduced carbon footprint and long service life. Spain needs to speed up FTTH reconstruction and backbone upgrades, build ubiquitous optical networks in cities, extend optical fiber to rural areas, and continue to improve the application of POL networks in connectivity infrastructure.

In smart hospitals, everything is interconnected, including the data center, outpatient area, nursing area, operating room, clinical laboratory center, and medical imaging center, leading to an exponential increase in connections. A POL network extends optical fibers to all corners of a hospital, including wards, consulting rooms, office desks, and medical equipment, and lays the foundation for the interconnection of devices, people, processes and data over the Internet (IoE).

1.4. Key Challenges

1.4.1. A progressive digitalization based on connectivity: the first institutional project "Health Online"

The evolution of Information and Communications Technology (ICT) services and utilities in the NHS has been a continuous and progressive process, which has evolved in line with technological innovations, especially the possibilities of establishing interconnection systems between the various centres and units. and of these to people entitled to health care.

The requirement of connectivity is inherent in the decentralized model of the system, since Spanish health care is widely distributed throughout the territory and its operational basis is to ensure continuity of care and safeguard the principles of universality and equity.

Initially, the first ICT-based corporate projects related to improving the management of clinical procedures that universally affect users and are a major part of care procedures.

The Health Online strategy document (an integrated programme within the Plan Moves Forward , an initiative launched by the Spanish Government to accelerate Spain's integration into the Information Society, published in 2005) detailed the implementation and evolution of the use of ICT in the NHS. This program was developed in two phases: Online Health I (2006-2010) and Online Health II (2010-2014). In both editions, the objective was to improve healthcare through the digitalization and interoperability of healthcare facilities and, by extension, the regional health services, with the participation of the public body Red.es.

This project was part of the NHS Quality Plan and the main objectives addressed included:

- Individual Health Card: Implementation of a unique identification system for all citizens protected by the NHS.
- Digital medical records: development of a common system for accessing patients' medical records from anywhere in the healthcare system.
- Electronic pharmaceutical delivery system: integration of prescribing, visa and dispensing processes.
- Telecitation: implementation of mechanisms to speed up users' appointments with family doctors, paediatricians and specialists.

- Telemedicine: Use of remote diagnosis and treatment devices to avoid unnecessary travel.

The program was able to make significant progress in several areas:

- Interoperability: developed a system that allows the exchange of clinical information between different regional health services and their healthcare centers.
- Citizen Access: Citizens and health professionals can access the Digital Medical Record online from any location, using their electronic ID or other digital certificate or credential issued.
- Electronic prescribing: An interoperable electronic prescribing system was put in place in the NHS, allowing medicines to be dispensed from any pharmacies in the country, regardless of where the prescription was made, and without requiring a paper document.
- Web and mobile applications: Some Autonomous Communities developed Virtual Health Card applications to provide additional features such as access to appointments, vaccinations, screening programs and satisfaction surveys.

The Health Online programme has made a significant contribution to establishing Spain as an evolving model for the application of ICT in health services. It has improved coordination between regional health services and has made it easier for citizens and caregivers to access health data and health resources in general. It proved to be a key initiative to modernise the NHS, improve the quality of healthcare and ensure the interoperability of information systems between the different Autonomous Communities. Supported by co-financing from the European Regional Development Fund (ERDF), it consolidated an innovative practice in the Spanish healthcare sector in the IT area, including the creation of new units and professional groups specializing in this field.

The three main practical contributions of this programme were the Individual Health Card (ISD), the NHS Digital Medical Record (HCDSNS) and the NHS Interoperable Electronic Prescribing (RESNS). There were significant synergies between policy and regulatory developments inherent in a public and universal system and technological capabilities, which were increased by innovation and the implementation of functional networks over the Internet.

In the *Annual Report of the SNS 2023 (published August 5, 2024, the latest available) is explicitly mentioned, and in a separate chapter for the first time in this series of publications, that "digital health continues to be strengthened through the National Health System's interoperability services, making electronic health records available to the public" Examples include:*

- The Autonomous Communities manage the IST through a common database; this interoperable card is the identification document of each person for accessing services and using services throughout the NHS and advances its use in digital format on mobile devices.
- The HCDSNS allows access to clinical documentation relevant to health care registered in any autonomous community, provided it is in an interoperable format. It can be accessed both by the patients themselves and by the healthcare professionals who must care for them. Citizen inquiries have doubled since July 2023, when access to the HCDSNS was introduced as a "My Citizen Folder" service, the general communication channel between the AGE and citizens.
- The interoperable electronic prescription service of the National Health System (RESNS) allows medication prescribed in any autonomous community to be dispensed by electronic means from any pharmacy. In 2023, 16,487,622 containers were dispensed to 2,298,998 different citizens in 6,926,305 dispensing events.

The NHS also exchanges medical records and electronic prescriptions with EU countries via the NHS node, a service already available in most of the Autonomous Communities and in a few Member States.

1.4.2. The Evolution of Digital Health

In 2020, at the height of the pandemic, the General Secretariat for Digital Health, Information and Innovation of the National Health System was created in the Ministry of Health through the Royal Decree 735/2020, of 4 August , which developed the basic organizational structure of the Ministry of Health. This Secretariat has the task of addressing projects to modernize, improve and transform the National Health System in the light of the new challenges arising from the COVID-19 pandemic, and particularly those related to digital health. interoperability and network services at national, European and international level, as well as health information systems. It is tasked with promoting and incorporating the capabilities of emerging next-generation technologies such as data analytics ("Big Data"), AI, predictive analytics, among others, in the healthcare field.

The TSI, RESNS and HCDSNS projects did the first thing in health digitalization to guarantee the exercise of health citizenship rights through technological systems for essential functions of the system itself. A second wave of technology needed to address improved health functionality through a holistic and holistic concept of digital health open to innovation.

A major milestone in digital health was reached in 2023 with the universal interconnection of the e-prescribing system and the creation of a centralised health portfolio covering the whole of the NHS. This breakthrough allowed patients, regardless of geographic location or health center, to access their medical records and electronic prescriptions in a unified, real-time manner.

> *In July 2024, the Government passed a new decree on the structure of the Ministry of Health (Royal Decree 718/2024, of 23 July), which strengthens the Digital Health structure, and the preamble to which states that digital technologies are a key element in strengthening the National Health System and thus in maintaining a high level of health in the Spanish population. New technologies, through their transformative capacity and incorporation into the health system, offer enormous potential for citizens, health professionals, health service providers and other related actors. Realizing these possibilities requires determined leadership from the Ministry of Health, with the appropriate organizational level, to ensure that technologies such as Artificial Intelligence or the Internet of Things are incorporated into the National Health System in an equitable and cohesive manner. ensuring interoperability, protecting personal rights and supporting the work of health professionals to help improve the quality, sustainability and resilience of health systems, collaborating nationally and internationally from the One Health perspective. The future European Health Data Area demonstrates the importance of its use as a key to quality, safety, ethical and sustainable healthcare and its use in research. development and innovation as incentives for Spain's productive fabric and the design and evaluation of health policies that provide the level of well-being that a leading country requires. This leadership will be provided by the National Health System's General Secretariat for Digital Health, Information and Innovation.*

1.4.3. NHS Digital Health Strategy

In 2021, the General Secretariat for Digital Health, Information and Innovation for the NHS drew up the *NHS Digital Health Strategy , which seeks to integrate digital technologies to improve the healthcare system in Spain, focusing on equity, efficiency, and innovation, and promoting collaboration and participation of all stakeholders.*

The document, the first with a cutting-edge view of Digital Health, focuses on four strategic objectives:

- Empower and involve people in their health care. Facilitate relations with health services and promote co-responsibility.
- Maximize the value of processes. Improve the performance and performance of the health

system, ensuring continuity of care and strengthening governance.

- Data management and governance. Create a National Health Data Space to generate scientific knowledge and evaluate services.
- Medicine-oriented innovation 5P. Implement innovation policies adapted to Population, Preventive, Predictive, Personalized and Participatory medicine.

In turn, the main pillars of the objectives and activities of the Digital Health Strategy are:

- Development of Digital Public Services in the Health Sector. It is intended to have a direct impact on promotion, prevention, health care and rehabilitation strategies. Digital services should be focused on usability, accessibility, and digital empowerment.
- Driving health information interoperability. The aim is to facilitate decision-making and quality of care, as well as strengthen the cohesion of the NHS.
- Innovation in healthcare. The aim is to transform the NHS towards a more personalized and participatory care paradigm, compatible with the sustainability of the system, through the 5P concept (Population, Preventive, Predictive, Personalized and Participatory).

Strategy's objectives are linked to the challenges of the NHS and are divided into four components: people, processes, data and innovation in health sciences. Ten areas of intervention are identified, such as risk surveillance, health promotion, health care, information interoperability, and the creation of a National Health Data Space, among others.

The proposed working model for Strategy involves the participation of the Autonomous Communities and the formation of multidisciplinary teams. The importance of involving healthcare professionals in the process of defining and selecting tools and information systems is emphasized.

The Strategy is aligned with other national and European plans, such as the Digital Spain 2025 Strategy, the Spanish Science, Technology and Innovation Strategy, and the Artificial Intelligence Strategy. The aim is to exploit synergies and coordinate actions to achieve the goals of digital transformation in health.

The implementation of the strategy is fundamentally linked to the implementation of funds associated with the "Recovery Assistance for Cohesion and Territories in Europe (REACT-EU)" and the "Recovery and Resilience Mechanism". is the reference framework for participation in other European Union programmes such as Horizon Europe, Digital Europe and Europe4Health.

The Strategy underlines the need to define and adopt shared models and standards in all areas where they do not exist, including Digital Medical History and ontology implementation. It also advocates the use of international open standards, with special reference to those supported by organizations such as UNE, CEN and ISO. Thus, the implementation of the NHS Digital Health Strategy builds on an existing robust regulatory framework but also calls for the development of specific new rules and regulations to address digital innovations in health.

Announcement of new legislation by the Minister of Health.

In the course of your appearance to present mandate plans of the Minister of Health, Mónica García, who took place in Congress on January 26, 2024, stated:

We will draft a digital health law to align the legal framework with the future European Health Data Area. This project was significantly promoted during the Spanish Presidency of the European Union. I would also like to inform you that we are working hard on integrating genomic medicine services in an integrated and uniform way into the common portfolio through the development of a catalogue of genetic and genomic tests that was launched this week along with the software application that underpins it. These tests are a fundamental pillar for the diagnosis, prognosis and treatment of diseases, especially rare diseases, and for the application of personalized medicine.

- **1.1 Digital in the Interterritorial Council of the National Health System.**

  The Interterritorial Council agreed in June 2021 the creation of the Digital Health Commission to help interoperability of all projects in this area.

  The purpose of the Commission is to contribute to co-governance between the Ministry and the Autonomous Communities in this area and to facilitate the adoption of agreements to ensure the compatibility of projects and initiatives by the various public administrations. The Commission will be composed of the Secretary General for Digital Health, Information and Innovation of the National Health System (SNS) and a representative from each autonomous community and city. Your work will be channeled. Through the newly created Digital Health Services and Technologies Sub-Committee and the Information Systems Sub-Committee, the NHS Information System Sub-Committee was renamed.

- **1.2. Digitization in other plans of the Ministry of Health.**

  In relation to digitization and information technology, several of the Ministry's most recent health planning documents address partial or useful issues in this area. The most relevant, in view of the impact of care, is the document Primary Care Action Plan 2022-2023 ", approved by the Ministry of Health in agreement with the Autonomous Communities, which mentions the following:

  - **Optimization of Administrative Processes. The aim is to re-engineer administrative processes in Primary Care to eliminate unnecessary steps, ensure that the most appropriate professional role performs each task, and enhance the role of administrative staff. In addition, it is intended to introduce information systems needed to make these processes more efficient.**
  - **Digitization Objective. Goal 4 of the plan is to boost information and digitalization systems in Primary Care. Within the framework of the Digital Health Strategy, it is planned to implement tools to facilitate healthcare in smart healthcare facilities through evaluated projects of teleconsultation, videoconsultation, Access to medical images and chatbots to improve citizen demand management.**
  - **History of Digital Health. Evolution of the electronic health record towards a Digital Health Record that is the focal point of the new Digital Health Services in the NHS, ensuring continuity of care, interoperability and exploitation of data. This story needs to be intelligent, integrating new technological capabilities and data sources such as IoT devices.**
  - **Smart Health Centers. Projects to strengthen the capacities of health centers, improve the quality of services for patients and facilitate professional work by providing services both inside and outside health buildings through a virtual and intelligent patient-centered care network.**

1.4.4. Digital Health in the Recovery, Transformation and Resilience (PRTR) Plan

Running until 2026, the PRTR aims to transform the Spanish economy and society by investing in four key areas: green transition, digital transformation, social and territorial cohesion, and gender equality through Next Generation EU funds.

It is structured around ten lever policies, which in turn give rise to 30 components, both regulatory and investment-enhancing. Within the sixth level, Pact for Science and Innovation. Strengthening the capacities of the National Health System is the Component 18 - Renewal and capacity-building of the

National Health System .

Component 18 includes a few initiatives related to digital, information and communication technologies in healthcare. The following is a detailed summary of the key issues related to these technologies:

- **Strategic Autonomy and Security. It highlights the inclusion of digital tools as a strategic basis for reforms in the health sector. This takes the form of building e-health services for both citizens and health professionals and digitizing public health administrations. Specific actions include:**
    - Automation of processes and information systems for decision making.
    - Improved security of stored information.
    - Improvements in information sharing with citizens.
    - Application of Big Data to generate knowledge about drug safety.
    - Extending the digital public service to citizens, professionals and interest groups.
    - Data generation and analytics infrastructure for healthcare R&D.
    - Artificial Intelligence applications and a collaborative platform to manage technological evidence.
  - **Creating a Sanitary Data Lake. This initiative seeks to create a data repository (Data Lake) that integrates information from multiple sources and devices. The main objectives are:**
    - Provide massive, real-time analysis to improve diagnosis and treatment.
    - Identify risk factors and patterns, predict health risk situations, and schedule resources.
    - Implement technological systems and platforms necessary to exploit information, including Artificial Intelligence algorithms.
  - **Modernization of Digital Health Services. It focuses on three main areas:**
    - Digital health services.
    - Network Health.
    - Interoperability of health information and exploitation of data.

Its objectives include enhancing the business intelligence of the National Health System (NHS), boosting digital health and national and international electronic interoperability, and providing the information systems needed to efficiently manage the services offered to citizens.

Projects and Specific Investments. These include, but are not limited to:

- **Technological Infrastructure:** acquisition of the necessary infrastructure to build the Health Data Lake and development of massive data processing projects by the Autonomous Communities.
- **Artificial Intelligence Applications:** Deploying AI applications for healthcare analysis and decision-making.
- **Collaborative Platform:** development of platforms for the management and dissemination of products of the Spanish Network of Health Technology Assessment Agencies (RedETS), facilitating collaboration and evaluation of health technologies.
- **Education and Training:** continuing education programmes for healthcare professionals in the use of digital technologies and information systems, ensuring the development of skills necessary for the digital transformation of the healthcare sector.

This Component 18 of the PRTR is strongly oriented towards the digitalization of the healthcare sector, seeking to improve efficiency, safety and quality of services through the implementation of advanced technologies such as Big Data, Artificial Intelligence and collaborative platforms.

1. **Health Data Lake:**
    - Objective: Create and operate a national health data system that will be available to at least

17 autonomous regions and cities. This system will allow massive data analysis to improve diagnosis and treatment.

- End date: Q4 2023.
- Responsible: MAETAD .

2. **National Digital Skills Plan:**
   - Goal: Adopt and implement a plan to provide digital skills training to the general population, reduce the gender digital divide, digitize the education system, and improve employability through digital skills.
   - End date: Q1 2021.
   - Responsible: MAETAD .

3. **Personalized Medicine Strategy:**
   - Projects related to personalized medicine, including general calls and specific programs, as well as a plan for advanced therapies.
   - Investment: EUR 140,500,000.
   - It includes projects for the internationalization of Spanish personalized medicine and collaboration in European programs such as Horizon Europe.

4. **Act on Equity, Universality and Cohesion of the National Health System:**
   - Objective: to adopt a law that promotes equity and cohesion in the health system by improving access to and rational use of medicines.
   - End date: Q4 2023.

5. **Public Health Surveillance Network:**
   - Objective: to create a public health surveillance network system to better respond to health crises.
   - End date: Q4 2023

6. **Digital Transformation of the Health Sector:**
   - Projects to digitize the health sector, including the provision of connected digital devices and interactive tools for students and classrooms.
   - Investment: EUR 960,000,000.
   - Goal: Improve digitization in terms of proactivity, mobility, user experience, automation, data-centric management, and cybersecurity.

These projects show a comprehensive approach to modernizing and digitizing the health system, investing heavily in information and communication technologies to improve the efficiency and quality of health services in Spain.

PERTE for Vanguard Health

As a result of the PRTR management model, the PERTE for Vanguard Health , approved by the Council of Ministers on November 30, 2021.

This PERTE involves reforming the functional capacities of the NHS and strengthening opportunities based on improved capture of science, technology and innovation. It envisages the design of a flagship Precision Personalized Health project and the strengthening of scientific and technological infrastructures to help create an internationally competitive health R&D&I ecosystem.

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LA VOZ DE LA INDUSTRIA DIGITAL

Due to the strategic nature of the health sector, the actions envisaged in this project are also reflected in other components of the PRTR, such as Component 11 (Modernization of Public Administrations) or Component 18 already mentioned. (Renewal and capacity-building of the National Health System).

- To position Spain as a leading country in the innovation and development of advanced therapies.
- Drive personalized precision medicine.
- Develop a digital National Health System with an integrated database to improve prevention, diagnosis, treatment, rehabilitation and research.
- Empower primary healthcare through digital transformation.

Commitments to the Operating Provisions.

Spain signed a commitment to implement the PRTR with the European Commission in the calls Operating Arrangements [2], provided for in the Recovery, Transformation and Resilience Facility Regulations. These reflect in greater detail the requirements, targets and deadlines for achieving and demonstrating compliance with the PRTR and are subject to assessment by the other Member States.

It should be noted, however, that the actions are being implemented late, partly because of the complexity of the actions. and another to the disruption in 2023 due to the electoral and government formation processes that took place that year.

1.4.5. Regulation

According to both the NHS's Digital Health Strategy and the plans contained in the PRTR, it is planned to develop the digitalization capabilities of Spanish healthcare based on existing legislation. as well as a new regulatory package, the main contents of which have already been planned.

Existing and applicable legislation

- Law 41/2002: regulates patient autonomy and rights and obligations regarding information and clinical documentation.
- Law 16/2003: promotes the cohesion and quality of the National Health System.
- Law 14/2007 on biomedical research.
- General Health Act No. 14/1986.
- Law 33/2011: General Public Health.
- Organic Law 3/2018: Protection of Personal Data and guarantee of digital rights.
- Royal Decree 1030/2006: establishes the common services portfolio of the SNS.
- Royal Decree 69/2015: creates the Register of Specialized Care Activity (RAE-CMBD).
- Royal Decree 183/2004: regulates the individual health card.
- Royal Decree 1277/2003: establishes the general base for the authorization of health centers, services and establishments.
- Royal Decree 1093/2010: establishes the Minimum Data Set of Clinical Reports (CMDIC) in the NHS.

Legislation planned or pending

- Digital Health Policy Project. The NHS Digital Health Strategy mentions the need to develop a digital health policy that regulates the relationship between health services and professionals with users, the incorporation of digital services and the secondary use of clinical information.
- Regulating AI in healthcare. The same strategy also highlights the importance of regulating the application of AI for therapeutic purposes, ensuring security and respect for privacy.
- Digital Health Act. Health Minister Mónica García, in her appearance in the Congress of Deputies to

[2] En Anexo II. Referencia de los principales compromisos del PRTR en el ámbito de la Salud Digital.

report on her department's priorities, announced the drafting of a Digital Health Law.

Initiatives in Autonomous Communities.

Several Autonomous Communities have taken actions in Digital Health (Table 1-1) in the exercise of their competences in health management. In some cases, these are integral plans and projects, while in others, specific regulations are foreseen.

Autonomous Community	Acting	Objectives	Status
Andalusia	Andalusia Digital Health Strategy 2024-2028	Become the first comprehensive strategy to define the digital model of the future and provide a global vision for the digital transformation of the Andalusian Public Health System, ensuring the correct distribution of responsibilities in the technology field to facilitate planning and avoid fragmentation and dispersion of the digital services offered and separation between existing needs and available solutions.	Proposal for the 1st Digital Health Strategy of Andalusia 2024-2028 (ESDA) in preparation, submitted to public consultation in March 2024.
Aragon	SaludInforma Digital Health Strategy	Openly, flexibly and innovatively regulate legal, ethical and technological challenges to ensure patients' rights in applying state-of-the-art advances to healthcare.	Introduced in March 2022.
Balearic Islands	Health Digital Transformation Strategic Plan	Turning direction towards a 21st century, predictive, preventive and personalized medicine involving citizens, eliminating bureaucratic and repetitive tasks.	Introduced in March 2024.
Cantabria	Draft Digital Health Bill	Openly, flexibly and innovatively regulate legal, ethical and technological challenges to ensure patients' rights in applying state-of-the-art advances to healthcare.	In preparation of the text, the preliminary draft was submitted to a preliminary public consultation in April 2024.
Castile-La Mancha	Digital Health Plan v	Improve and evolve digital health services, facilitate decision-making and support the modernization of health processes.	In the making.
Community of Madrid	Digital Health Plan	Harness the benefits of technology to take care wherever the patient is, shorten waiting times, reduce unnecessary travel and, in general, facilitate monitoring of the health of the people of Madrid at every check-up, at every appointment. in every test.	Announced in March 2023.
Valencian Community	Digital Health Strategy	Seize the opportunities offered by new technologies in healthcare and create an intelligent health system that can better respond to the current needs of the population.	In preparation, according to statements made by Health Minister Marciano Gómez (see here)
Galicia	Department of Health's Digital Health and Transformation	Transform and evolve the model of care for citizens with the necessary support for health professionals, enabling them to	Approved June 2023.

Autonomous Community	Acting	Objectives	Status
	Strategic Plan 2023-2026	respond to the challenges of the sector and the population.	
La Rioja	Community Health Strategy in Primary Care of La Rioja 2023 – 2027	It includes the deployment of digital tools as one of its seven lines of action.	Introduced in June 2024.
Murcia	PRIMARY CARE IMPROVEMENT STRATEGY (EMAP) 2023-2026	One of its strategic thrusts is to strengthen digital transformation in order to achieve more efficient Primary Care.	Published March 2023.
Basque Country	EUSKADI Health Plan 2030	Principle that assistance supported by advanced digital services can increase accessibility to a wider range of services for large segments of the population.	Approved June 2023.
Galicia	Department of Health's Digital Health and Transformation Strategic Plan 2023-2026	Transform and evolve the model of care for citizens with the necessary support for health professionals, enabling them to respond to the challenges of the sector and the population.	Approved June 2023.
La Rioja	Community Health Strategy in Primary Care of La Rioja 2023 – 2027	It includes the deployment of digital tools as one of its seven lines of action.	Introduced in June 2024.
Murcia	PRIMARY CARE IMPROVEMENT STRATEGY (EMAP) 2023-2026	One of its strategic thrusts is to strengthen digital transformation in order to achieve more efficient Primary Care.	Published March 2023.

Table. Initiatives of the Autonomous Communities1-1

1.4.6. European context

The European Union (EU) has also recognised digital technologies as fundamental to the Union's economic and social development, with the initiative *Europe Adapting to the Digital Age* one of the Commission's six policy priorities for the period 2019-2024. Addressing areas such as mobility, industry, the environment and energy, he argues that digital transition must benefit everyone, put people first and open up new opportunities for businesses. Health is also one of the sectors covered by this strategy.

The Communication from the European Commission (EC) on achieving the digital transformation of healthcare and care in the Digital Single Market, empowering citizens and creating a healthier society , adopted in April 2018 and subsequently by the European Parliament in December 2019, outlines how the EU can contribute to achieving the goals of digitising the healthcare and care sectors. Primarily, it seeks to improve the digitalization of the health and care sectors based on three pillars: accessing and exchanging secure data; connecting and sharing health data for research, faster diagnosis and better health; and strengthening citizen empowerment and individualized attention through digital services.

In this way, the EC establishes a high-value model for knowledge generation, integrating healthcare data (such as medical records and electronic prescriptions), telemedicine, and advanced digital technologies (such as 4G/5G, Artificial Intelligence and supercomputing) in common space. Thus, the European Data Strategy proposes to create a European Health Data Space to, inter alia, facilitate better treatment of chronic and rare diseases and ensure equal access to high-quality health services for all citizens.

The first EU Common Data Space in a specific area to emerge from this strategy is the European Health Data Area (EEDS) with the aim of facilitating access to and exchange of health data across borders, both to support healthcare delivery ("primary use of data") and to inform healthcare research and policy-making (reuse of data or "secondary use of data"). It was introduced in a proposal for a regulation published by the European Commission in 2022 and in March 2024, the European Parliament and the Council reached a political agreement, approved by the European Parliament in April 2024. The interim agreement still needs to be formally approved by the Council, after which it will have to be published in the EU's Official Journal and will enter into force twenty days later. It will apply two years later, with some exceptions.

1.4.7. Private Healthcare Vision

The Institute for the Development and Integration of Health (IDIS) Foundation, which acts as the employer of private health care, has been calling for a more active policy on interconnectivity. Its vision is that the ability to connect the systems of all health resources in the system, regardless of whether they are public or private, would improve the effectiveness, efficiency and effectiveness of the delivery of services to citizens.

In October 2015, the IDIS Foundation published the I *Interoperability in the Healthcare Sector. The Patient as the Main Player* , which analyzes the role of private healthcare in the Spanish health system and addresses the challenges and opportunities facing this sector, underlining the importance of effective collaboration between public and private healthcare to optimize resources and improve health outcomes.

Among the lines of improvement, it proposes the creation of new services based on the NHS Digital Medical Record, the promotion of standards for interoperability and the use of ICT applied to the management of chronic diseases.

1.5. Healthcare Networks Market Predictions

1.5.1. Hospital Market Prediction

According to the Ministry of Health's National Hospital Catalogue, Spain has 840 hospitals in operation, totalling 159,587 beds. Of these 449 are public hospitals with a total of 114,671 beds.[3,4]

In the coming years, the turnover of the hospital sector is expected to grow steadily, driven by a number of factors such as an expanding supply, rising prices, an ageing population and growing demand from abroad. These elements will help to counter the challenges of political and economic uncertainty at both the national and international levels, forecasts of a gradual slowdown in the economy, continued high

[3] https://www.sanidad.gob.es/estadEstudios/estadisticas/sisInfSanSNS/ofertaRecursos/hospitales/docs/CNH_2024.pdf
[4] https://www.sanidad.gob.es/estadEstudios/sanidadDatos/tablas/tabla22.htm

inflation and high interest rates.

According to the Banco de España, gross domestic product is expected to grow by just under 2% annually in 2025, below the growth achieved in previous years, while household consumption is expected to increase by 2% in 2025. In this context, the Healthcare sector's annual turnover is expected to grow by around 4%, exceeding €14 billion for the first time.

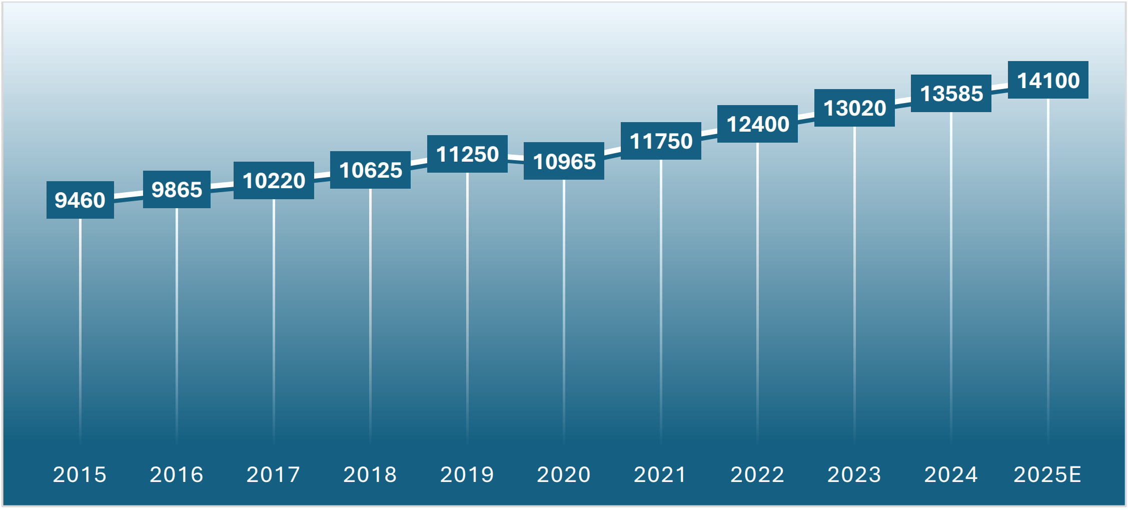

Figure 1-1. Total Health Billing Trends in Spain

The insurers contract segment will continue to lead the sector's dynamism, growing at an estimated 4-5% annually in 2025, driven by strong developments in the health insurance market. This business will reach nearly 8 billion euros in the last year.

On the other hand, revenue from public concerts will increase at an average rate of around 4% per year over the same period, reaching around €4.8 billion by the end of 2025.

Pure private sector turnover will grow by approximately 2% in 2025, bringing a turnover of around €1,325 million by the end of the period.

Companies that have shared their forecasts for these years anticipate moderate increases. Some of them stand out, with growth forecasts of between 4% and 6% per year by 2025. IMQ, meanwhile, expects moderate growth in 2025 of between 1% and 3%.

Increased revenues, coupled with improved productivity and efficiency, will have a positive impact on profitability, offsetting the effect of higher costs and greater customer price sensitivity.

1.5.2. Total Campus POL Market Prediction

A campus network refers to the integrated system that enables communication, control, and coordination between devices on one or more campuses, providing a unified platform for accessing different resources and collaborating on projects. Globally, the network market for campus environments was valued at $26,825 million in 2023 and is expected to grow at a compound annual rate (CAGR) of 7.6% in the coming years. POL technology is emerging as a key solution due to its wide range of applications.

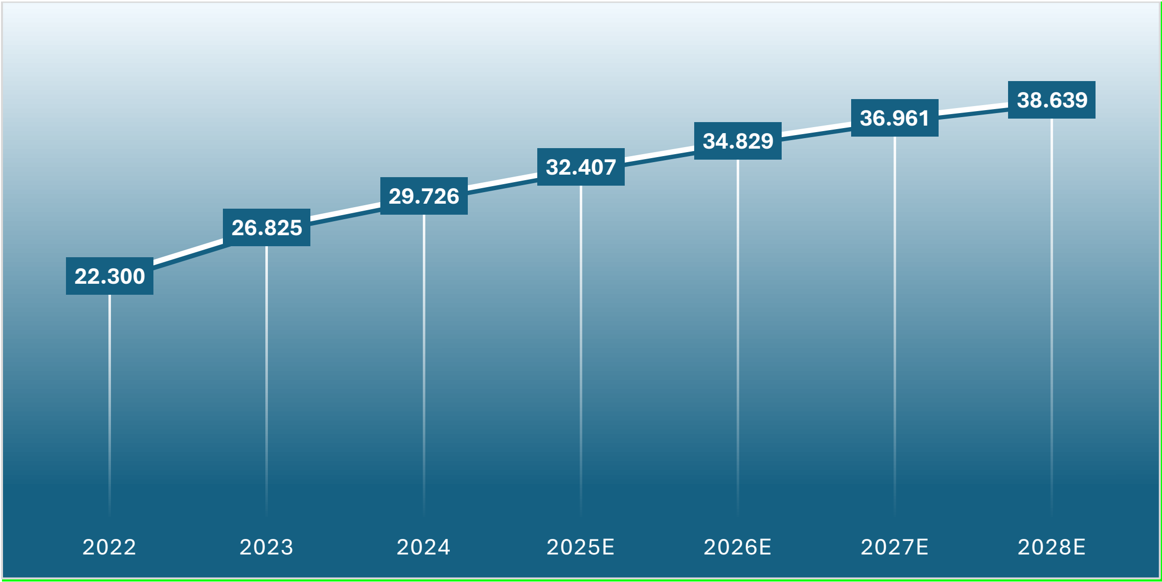

Figure 1-2- Global Enterprise Network Equipment Market ($M)

Source:Gartner Market Statistics,Forecast:Enterprise Network Equipment by Market Segment,Worldwide,2022-2028,1Q24 Update)

Spain's campus networking market is experiencing remarkable growth, reaching a value of $1,141 billion in 2023. According to a recent market analysis, it is projected to grow at a compound annual rate (CAGR) of 11.0% over the next few years. This growth is mainly driven by increased demand for cloud computing from SMEs, increased government regulation of data security, and increased investment from domestic investors.

Thanks to Spain's efforts to drive the adoption of FTTH technology, this solution has established itself as the most successful home access technology in Europe. The expansion of broadband and cable networks has enabled high-speed Internet access at competitive prices, encouraging digitization and contributing to economic growth. In addition, it is estimated that by 2025 100% of the Spanish population will have access to high-speed broadband. This development will improve the connectivity of enterprises and industrial estates, while incentives such as vouchers will make it easier for SMEs to adopt digitalisation.

POL technology will play a key role in the evolution of campus networks, adapting to the increasing demands for bandwidth, low latency, and higher traffic volumes in data centers. The expansion of these centers has driven the need for high-performance switches, and adoption is expected to grow significantly.

According to Gartner, the enterprise campus network market share forecast for 2022-2028 reflects continued growth as shown in Figure 1-3.

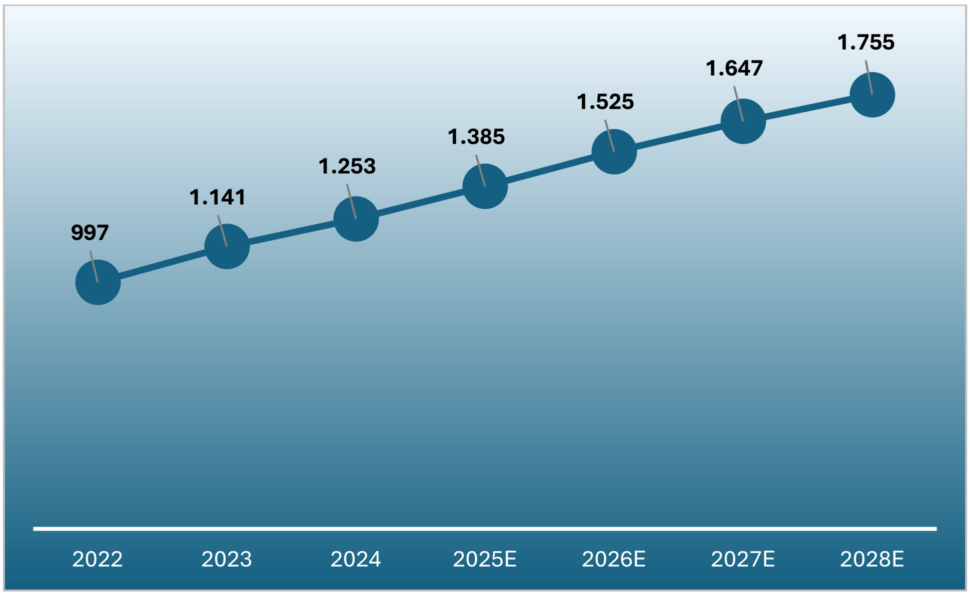

Figure 1-3 Forecast: Global Enterprise Network Equipment Market ($million). Source:Gartner Market Statistics,Forecast:Enterprise Network Equipment by Market Segment,Worldwide,2022-2028,1Q24 Update)

The medical campus network is undergoing a comprehensive digital transformation. With the proliferation of different types of medical devices, the quality, accuracy, and frequency of data collection are continuously improving. This advancement is leading to new architecture and applications, such as distributed data storage and Big Data models, that demand greater capabilities from the digital infrastructure. As one of the main channels of information transmission and management, the campus physician network will play an increasingly crucial role in ensuring health care.

1.6. Standards in the Digitalization of the Healthcare Sector

Standards play a key role in digital health planning, design, implementation, operation, and governance. They help ensure that data is consistently collected, stored, and shared, which is essential for the integration of health information systems. They also provide a framework for developing inter-system interoperability, allowing a patient's health data to be shared between health professionals in different organizations while retaining its original meaning and context. to allow continuity of care between levels and between jurisdictions. They also play a key role in improving access, quality and safety of health care, as well as facilitating clinical research, epidemiology and public health.

Another key benefit of adopting digital health standards is that they make it easier to achieve data security and privacy protection for patients from the risks of cyberattacks and data breaches by establishing safe transmission and storage practices preventing the loss of sensitive information.

In addition, standards can promote innovation in digital health by providing a common platform for developers and vendors. This reduces the time and cost associated with developing new digital health technologies, enables faster deployment and dissemination, facilitates scaling of solutions, supports sustainability, and strengthens the resilience of health information systems.

Digital health ecosystems are very complex due to the very complexity of health systems and the wide variety of applications covered by ICTs in health, their heterogeneity, the diversity of information types involved, the possibilities for interconnection and the large number and diversity of users. both professionals and the population served.

Digital health standards play a key role in:

- Facilitate the interoperability of information and processes across the various domains of health and general health.

- Provide continuity of care between different levels of care and organisation.
- Making precision medicine possible in the NHS through widespread use of clinical and genomic information together.
- Generate localizable, accessible, interoperable, and reusable quality data sets (FAIR, Findable, Accessible, Interoperable, Reusable principles) for use in research and public health, to improve the quality of care and the effectiveness of investigations.
- Enable the creation of the National Health Data Space for mass processing and analysis and the establishment of conditions and resources for the generation and extraction of knowledge.
- Support the efficient provision of safe, coordinated, high-quality health services to individuals and the population where and when needed.
- Ensure data security and protection and patient safety.
- Enable cross-border health services and research.
- Develop the national and European market for digital health systems by making them more competitive.

In addition, the healthcare sector is a heavily regulated sector that uses standards to demonstrate compliance with the technical requirements of the regulation. European legislation such as Regulation (EU) 2017/745 on medical devices, Regulation (EU) 2017/746 on in vitro diagnostic medical devices and numerous national legislations use standards (see AEMPS or Public Health - European Commission for more information).[5][6]

The use of standards in the digital transformation of the healthcare sector is reinforced by the NHS Digital Health Strategy (sanidad.gob.es) or the European Health Data Area - European Commission (europa.eu), which rely on standards as an essential technical tool for effective implementation.[7][8]

However, the deployment of these digital health strategies and regulations will only be possible if the underlying communications infrastructures can support the growing data traffic with the necessary speed and reliability, and that is where POL network applications for smart hospitals come in. The proposed solution must take into account the existing standards in order to integrate smoothly into the intended environment and be translated into a standard that guarantees the quality of its development and generates the confidence that allows its deployment in an environment that is very accustomed to the use of standards. More information on the use of standards for healthcare digitization can be found on the UNE website[9].

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[5] https://www.aemps.gob.es/la-aemps/legislacion/legislacion-sobre-productos-sanitarios/
[6] https://health.ec.europa.eu/index_en
[7] https://www.sanidad.gob.es/areas/saludDigital/doc/Estrategia_de_Salud_Digital_del_SNS.pdf
[8] https://health.ec.europa.eu/ehealth-digital-health-and-care/european-health-data-space_es ; https://www.consilium.europa.eu/es/press/press-releases/2025/01/21/european-health-data-space-council-adopts-new-regulation-improving-cross-border-access-to-eu-health-data/
[9] https://www.une.org/normalizacion_documentos/Estandares_salud_digital.pdf

2. POL Network Applications for Smart Hospitals

2.1. Major Applications of the POL Network for Smart Hospitals

Smart hospitals are based on many information systems, including Hospital Information System (HIS), Electronic Medical Record (EMR), Image Archiving and Communication Systems (PACS), Health Information Locator (LIS), and General information such as video return system, parking management system, access control system, automatic fire alarm system, and building control system. Hospital informatization is moving from Information Technology (IT) to Data Technology (DT), and the convergence of service data is making siloed networks and data integrated, highly available, simplified, and intelligent. The multi-layer network architecture of a traditional network increases network latency and complicates network deployment. In this context, hospitals urgently need a network that enables data convergence, simplified architecture, and rapid deployment.

The Figure 2-1 Intelligent Hospital Technical Architecture_shows a generic architecture of a smart hospital. At the top are so-called 'smart applications', which are basically applications that manage all kinds of infrastructure. These intelligent applications include hospital operations center (HOC), dean's cabin, intelligent management center (providing intelligent management of assets, personnel, vehicles, water, electricity, and gas) smart health center (big data medical research provision, smart classroom, learning resource platform) and intelligent service center (providing standardized medical services such as Internet hospital, medical consortia, and smart guidance).

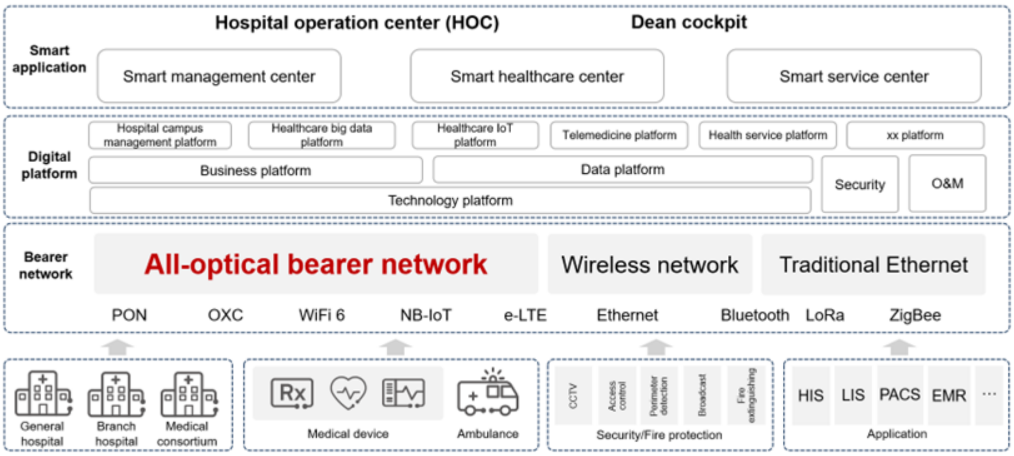


Figure 2-1 Intelligent Hospital Technical Architecture

Just below intelligent applications are digital platforms that include the technical platform, service platform, and data platform. First, the technical platform provides the service platform with general technical capability components, such as the hybrid integration platform, the microservices framework engine, and the Big Data platform. Second, the service platform includes the basic domain, the service domain, and the administration (operation) domain, the public domain, and the interface domain. They are developed, tested, and deployed in a hybrid cloud microservices framework and engine, and registered, invoked, and released as assets through the hybrid integration platform. Finally, the data platform is an important foundation for data interconnection, integration standardization, interactive sharing, and structuring.

The bearer networks in Figure 2-1 include wired (such as POL and Ethernet) and wireless networks and related technologies.Figure 2-1 Intelligent Hospital Technical Architecture

The case of this White Paper focuses on a POL network, the high-level scheme of which is shown in Figure 2-2. An intelligent hospital POL network has a simplified network architecture based on passive optical fiber transmission media. Smooth evolution of capacity and easy operation and maintenance. Figure 2-2 shows that the intranet, extranet, and security network of a hospital can be converted into the same infrastructure while meeting all the requirements of each service. In addition to supporting intelligent evolution and data convergence of a hospital, a POL network can isolate subnets by time interval or wavelength, ensuring hierarchical network security protection for different application services.

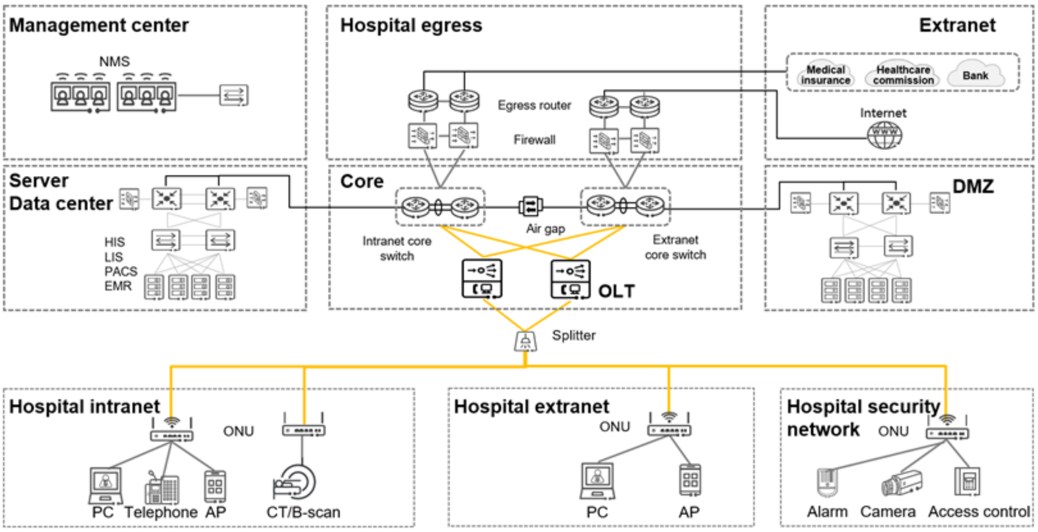


Figure 2-2. Typical architecture of a hospital POL network

Although the POL network has so far been referred to as a PON network, it can consist of multiple physical PON networks to separately carry the intranet, extranet, and security of an intelligent hospital. A POL network also supports Optical Transport Network (OTN) technology, which can connect multiple campuses of an intelligent hospital through a private metropolitan healthcare network. Subsequent subsections will provide more details about each type of service/network.

2.1.1. Hospital Intranet

The hospital intranet is a network dedicated to medical information and is intended exclusively for in-house staff. A hospital intranet carries intelligent healthcare data and most intelligent management services, such as HIS, EMR, LIS, PACS, and HRP systems.

As the core network of a hospital, a hospital intranet should cover the consulting rooms and wards of each clinical department, medical technology department, office area and public area (Figure 2-3). The POL solution can effectively support various services on the hospital intranet.

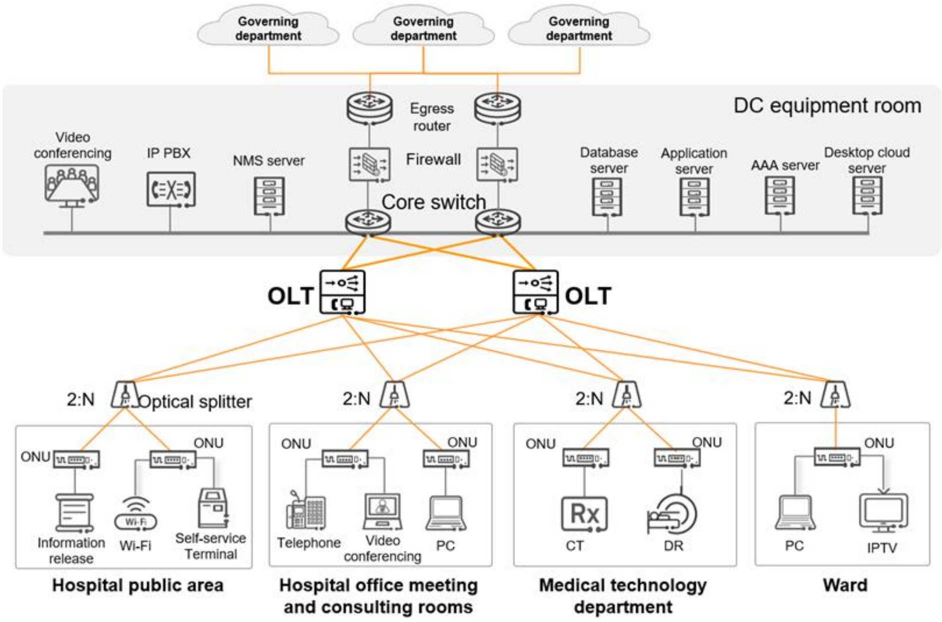


Figure 2-3. Typical topology of a hospital intranet over POL

An intelligent hospital intranet can be built using the POL solution to provide fast, secure, and high-speed network connections. Terminals such as PCs, printers, self-service devices, tablets, PDAs, and Access Points (APs) in outpatient, emergency, medical technology, hospital, administrative, scientific research and teaching are connected to the data center for quick access to various hospital servers. This ensures that tasks such as check-in, number-taking, triage, waiting, payment, medication dispensary, nursing, examination, and treatment are implemented efficiently and in real time. As a result, healthcare professionals can effectively balance workloads while reducing patient waiting times and increasing patient satisfaction.

In a POL network, Optical Network Units (ONUs) provide Plain Old Telephone Service (POTS) ports to connect to common voice phones and standard Ethernet (GE/10GE/25GE) ports to connect to various medical and office devices. such as bulletin boards, self-service printers, and Wi-Fi 5/6/7 access points in public areas; videoconferencing terminals, PCs, and printers in offices and consultation areas; high-end medical imaging devices such as DR (Mobile Digital X-ray Unit) scanners, CT (Computed Tomography), MRI (Magnetic Resonance, PET (positron emission tomography) and SPECT (single photon emission tomography) in the medical technology department; and other terminals such as PCs and Internet Protocol Television (IPTV) in the rooms.

The Optical Line Terminal (OLT) and ONUs are connected through a passive Optical Distribution Network (ODN) to provide high capacity, reliability and flexible network coverage. OLTs convert or aggregate the information received from ONUs and send it to intranet core switches. Intranet core switches are connected to multiple servers (including application servers, storage servers, and management servers) in a central equipment room to implement authentication and access control for multiple terminals, and store and invoke service data. Central intranet switches can also be connected to administrative departments such as the National Health Commission, Medicare, and disease control departments through firewalls and outbound routers.

In a POL network, the adopted PON technology varies according to the application scenarios. For example, you can use GPON (or XGS-PON if conditions allow) in rooms and offices. In imaging scenarios that require large bandwidth both upstream and downstream, XGS-PON can be used to provide a symmetrical capacity of up to 10 Gbit/s depending on the number of connected users or devices. meeting the image data transmission requirements of high-end medical imaging devices such as DR, CT, MR, PET, and SPECT, enabling fast access to image data.

Even as a highly reliable type of infrastructure, a POL network is capable of supporting different modes of failover protection. For example, it may be the case that an OLT fails, or a fiber is damaged. For this purpose, it is proposed to work with protection modes called Type B and Type C dual-homing, each of which offers different levels of protection. It is important to select the protection option that best suits the application scenario on the hospital intranet, either Type B or Type C protection.

On the other hand, dual-homing type B protection provides redundancy (duplicity) in the optical power cables (feeder), the PON ports of an OLT, the entire OLT, the upstream ports of an OLT and upstream optical fibers. In addition, dual-homing Type-C protection protects the PON ports of an ONU, distribution fibers (branch fibers), optical splitters, power cables, PON ports of an OLT, the entire OLT, the upstream ports of an OLT and upstream optical fibers.

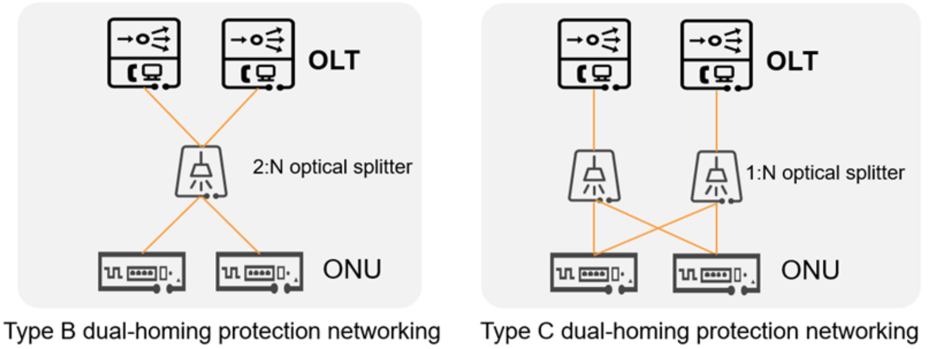


Figure 2-4.Type-B and Type-C dual-homing protection for a POL network

Thus, in the case of a hospital intranet where a POL network is to offer greater reliability, it is recommended to implement any of these types of protection, whether dual-homing type B or type C. to ensure reliable and stable signal transmission at all times.

2.1.2. Hospital Extranet

The hospital extranet is primarily used to provide Internet access and Wi-Fi connectivity in areas such as administrative offices and public spaces, facilitating communication and access to information for healthcare professionals, patients and visitors alike. The network also provides key external services such as medical appointment and treatment management, online follow-up consultations, newsletters, and access to medical results. allowing patients to conveniently and remotely manage different aspects of their healthcare. In addition, the extranet supports the development of telemedicine by offering remote medical consultations, improving access to care for patients who cannot physically come to the hospital.

With the advancement of the "Internet + Healthcare" initiative, many hospitals have created virtual hospitals over the Internet, implementing a wide range of intelligent service features such as online booking, consultation, and payment, improving patient experience and streamlining hospital processes.

Figure 2-5 shows a typical typology of a hospital extranet on POL. In these configurations, the POL network can efficiently transport the external network of the hospital to cover administrative offices, public areas, medical offices, nursing stations, and wards, providing high-speed Internet access. This external network can exchange information with the hospital's internal network through security devices, thus meeting enhanced data protection requirements and providing intelligent health services for patients.

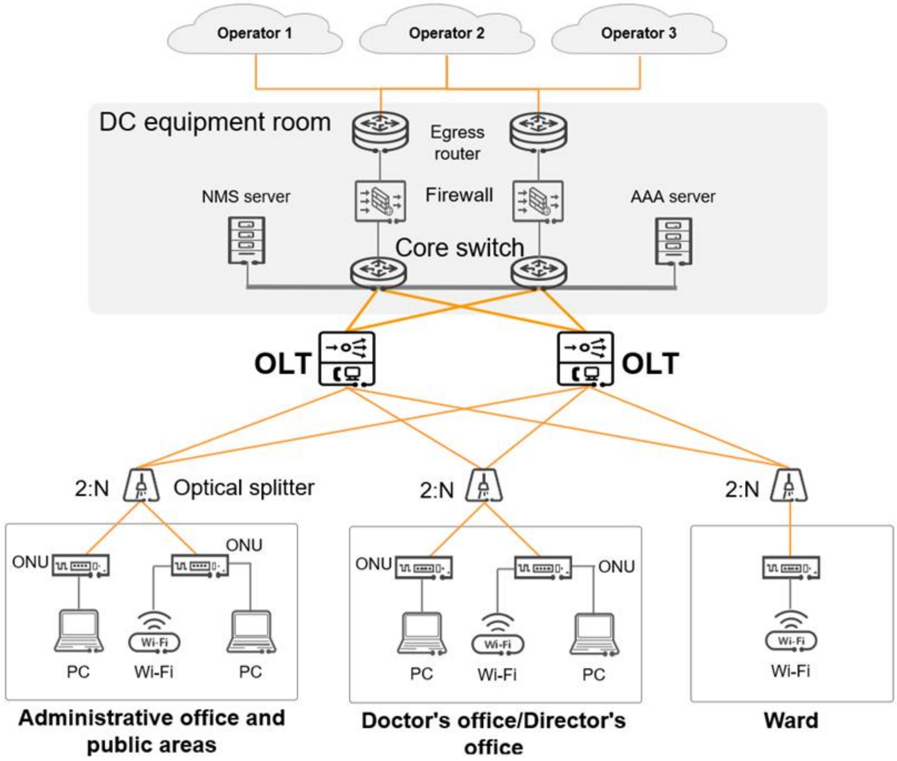


Figure 2-5. Typical topology of a hospital extranet over POL

An intelligent hospital extranet is built using the POL solution to provide secure, high-speed Internet access. In this type of network, ONUs provide standard Ethernet ports (GE/10GE/25GE/GE) that connect to various Internet access devices, such as Wi-Fi access points and PCs in public areas, as well as Internet terminals in medical offices and administrative areas. They also include Wi-Fi access points in the rooms as part of the extranet. OLTs and ONUs in a POL network are connected through a passive ODN to provide high bandwidth and reliability. OLTs convert or aggregate the information received from ONUs and send it to the extranet core switch. This extranet core switch connects to a carrier network through the firewall and egress router to access the high-speed Internet.

Thus, a hospital extranet can be built as an independent all-optical network or share a physical PON with the hospital intranet. When the intranet and extranet of a hospital share a physical PON, service isolation can be achieved through timeslot interval and dedicated hardware forwarding resources to meet security requirements.

2.1.3. Hospital Security Network

As occasional security incidents occur, whether due to technology failures or vulnerabilities, implementing a security system that is both reliable and cost-effective becomes increasingly crucial for organizations. This is especially relevant in the key areas of smart hospitals, where large volumes of sensitive data are handled. An efficient solution not only protects the infrastructure but also ensures medical data privacy and business continuity.

According to the technical requirements for hospital security systems, the horizontal resolution of the hospital CCTV must be greater than or equal to 400 TV lines (TVL), the pixel of the images must be greater than or equal to 704 x 576 and the subjective assessment of the image quality should be greater than or equal to level 4. Generally, the HD images of hospital CCTVs have a resolution of not less than 720p, resulting in high data traffic of long duration and high requirements on the bearer network. A security network should provide long-distance transmission to support video backhaul from different buildings and hospital campuses, access control in key areas, and parking management.

Generally, an intelligent hospital security system is deployed separately. Figure 2-6 shows an example of a security network with POL infrastructure. A POL network uses optical fibers for transmission, which breaks the 100 m distance limit of Ethernet cables and supports a transmission distance of up to 40 km. Long-distance coverage and high bandwidth make POL an ideal solution for building a hospital safety network. A security network can also share a physical network with the hospital intranet, but they must be isolated from each other.Figure 2-6. Typical topology of a hospital safety network over POL

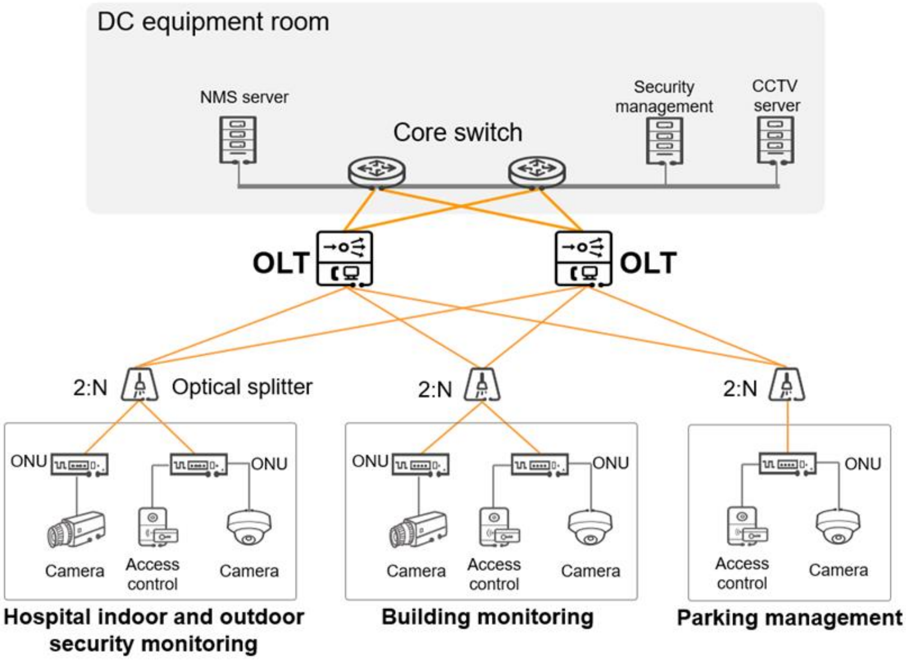


Figure 2-6. Typical topology of a hospital safety network over POL

In a hospital security network, ONUs provide standard Ethernet ports (10GE/GE) to connect to various management devices, such as CCTV and access control devices. ONUs also provide the power over Ethernet (PoE) function to supply power to devices such as CCTV. The OLTs and ONUs of a hospital security network are connected through a passive ODN to provide high bandwidth and reliability. OLTs convert or aggregate the information received from ONUs and send it to the video backhaul server through a core switch.

A POL network supports eMDI measurement and offline camera detection. It can quickly locate problems such as artifacts and black screens on CCTV and carry out efficient security services, performing real-time monitoring and management of hospital areas.

2.1.4. Metro Private Health Network

Typically, smart hospitals can have multiple campuses and/or buildings that are distant from each other. For this, OTN technology can be used to build a stable private metropolitan health network (e.g., data exchange ring network) to provide high-speed interconnection to share data and resources between remote campuses/buildings implementing a POL network. Figure 2-7.shows an example of this type of interconnection between different campuses.**¡Error! No se encuentra el origen de la referencia.**

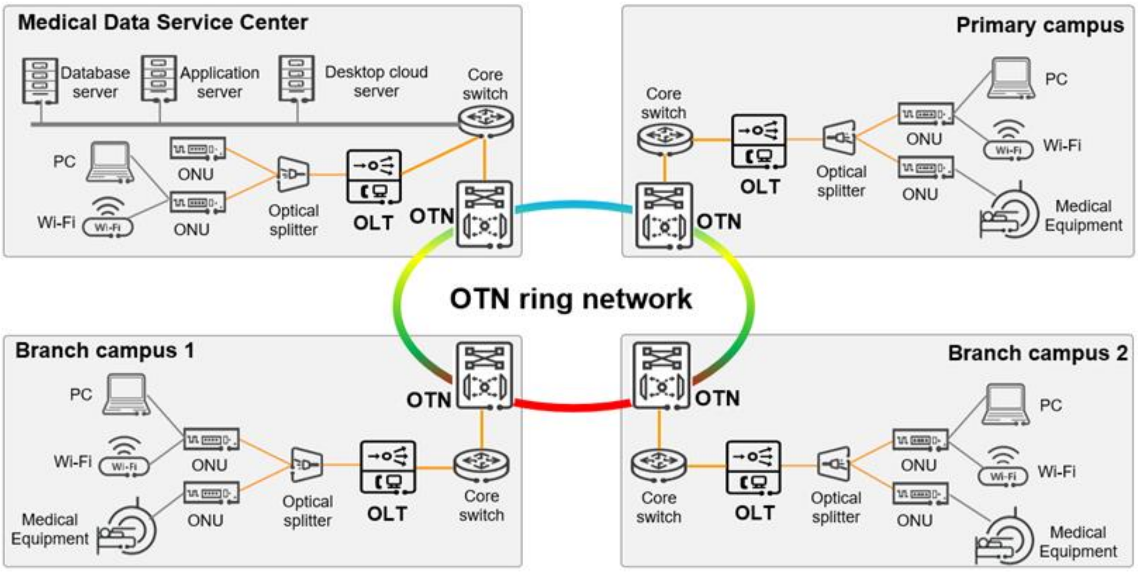


Figure 2-7. Topology for multi-campus interconnection over POL

In this metropolitan private healthcare network, each hospital campus has its own routers, core switches, OLT/ONU, and OTN devices. An example could be that an intelligent hospital leases optical fibers to operators and builds an OTN ring network to connect several hospital campuses to have its own dedicated network and efficiently share data. To design this OTN network, let us consider the development requirements of a hospital today. In this case, you are advised to configure the ring for 40 wavelengths, each of which operates at 100 Gbit/s. In this way, the OTN ring can be easily scaled up to 80 wavelengths, also operating at 100 Gbit/s each. By building this metropolitan healthcare private network, an intelligent hospital can converge multi-campus networks to implement unified planning and management, and achieve reliable, high-speed data interconnection and access across campus networks.

A private healthcare metropolitan network provides an intelligent hospital with high transmission bandwidth, low latency, flexible multi-service scheduling, easy scalability, and high system reliability, meeting the requirements of interconnection and long-distance inter-campus access.

2.2. Use Cases

This section describes several use cases where POL networks prove their value, providing effective and customized solutions across multiple industries. Each use case includes a detailed description of the users involved, the challenges they face, the context in which the POL network operates, its scope and the benefits it brings to the organization or community. They also include situations where POL networks have improved communication and security in mass events, operational efficiency in healthcare facilities, communication in emergency environments, and device interconnection.

This section describes how POL networks adapt to the specific needs of each situation, providing reliable and secure coverage for critical communications and demanding applications. It also highlights the ability of these networks to facilitate the integration of different devices and systems, as well as their potential to address technological and societal challenges in the context of digital transformation.

Use Case	Optical fiber network infrastructure for digital teleradiology in the hospital
Users involved	Patients, Radiologists, Hospital Health Professionals and Primary Care Practices, Clinicians.
Challenges, Context, and Scope	Teleradiology is a specialty and one of the most important aspects of telemedicine, which is defined as the electronic transmission of radiological images (tomography, x-ray, magnetic resonance imaging, etc.) from one location to another for the primary purpose of interpreting or consulting a diagnosis. The advantages and benefits are as follows: • Faster diagnosis of patients. • Cost savings for hospitals and medical centers. • Collaboration between health professionals around the world in patient care, research and training. Teleradiology generates large amounts of images and data, requiring a robust, high-speed network infrastructure to support data traffic. Shipment size is expected to continue to grow in the coming years, requiring more storage capacity and bandwidth. Optical fiber is the network technology best suited to meet these needs because it offers much greater bandwidth than traditional copper networks.
System requirements and communications technical considerations (Latency requirements, bandwidth...)	Teleradiology is based on a number of technologies and requires the following elements: • Image loading station at the location where images are taken. • Telecommunications technology for image transmission and sharing. • Interoperability technology and messaging of images and data between hospital and laboratory systems. • Image viewing stations on the outside where a qualified health care professional will view the images. The basic services supporting the Integrated Network of Teleradiological Services (RIST) include: telediagnosis, teleconsultation, telemonitoring and telemanagement. Another service provided by RIST is access to high-performance computer systems to facilitate intensive image analysis and associate database systems with valuable educational materials. In recent years, AI has been actively introduced into the teleradiology technology chain, helping radiologists analyze image records and data faster and more accurately to better understand patients' condition. The requirements of an optical fiber network infrastructure for teleradiology are as follows: • High-speed connection. • Low data transfer latency. • Security and protection against unauthorized access to patient data. • Scalability to accommodate ever-increasing volumes of data.
Expected results	Due to the use of a higher bandwidth network that provides high-speed connections, improvements are expected in many critical components of teleradiology technology: 1. Availability of remote diagnosis using ever-increasing images. 2. Support the increasing data traffic generated by teleradiology

Use Case	Optical fiber network infrastructure for digital teleradiology in the hospital
	technologies. 3. Reduce latency during data transfer. 4. Improved resolution of transmitted images. 5. Improving the quality of teleconsultations via teleconferencing. 6. Accelerated adoption of AI tools for teleradiology that require secure, high-speed BIG data flow. Given that rapid and accurate diagnosis of patients is a key element in improving health services, and given the current level of use of teleradiology, the expected effect of the introduction of fibre for teleradiology needs will have the most significant effect on improving the capabilities of digital hospitals.
Results obtained	

Ametic
LA VOZ DE LA INDUSTRIA DIGITAL

Use Case	Home hospitalization (or approaches that mix home care and telematics) and the need for advanced telecommunications
Users involved	Patients in home hospitalization (HD) programs who have conditions that allow for remote treatment, such as fractures or leukemia. Health professionals, such as doctors, nurses, and technicians, who monitor and care for patients remotely. Home caregivers who care for patients in their home environment and work with health professionals to ensure quality and continuous care.
Challenges, Context, and Scope	One of the main challenges is to ensure the fast and reliable transmission of large amounts of medical data, which is crucial for real-time monitoring and informed decision-making by healthcare professionals. In addition, technology needs to be adapted to clinical practice without interrupting existing care processes, while ensuring the privacy and security of patient data. Contextually, home hospitalization and telemedicine are booming, driven by the need to reduce costs and improve patient comfort. Examples such as the Infanta Leonor Hospital in Madrid demonstrate the viability and benefits of these innovative models of medical care.[10] The scope of this case includes the implementation of POL-type optical networks to support the telecommunications needs of hospitals. This involves integrating telemedicine systems and managing patient data, ensuring that medical professionals can quickly and securely access necessary information.
System requirements and communications technical considerations (Latency requirements, bandwidth...)	System requirements and technical communications considerations for implementing the wallless hospital use case will largely depend on the specific applications being deployed. Low latency is now essential to enable real-time monitoring and lag-free communication between patients and healthcare professionals. In addition, high bandwidth is required to support the transmission of medical data, including high-resolution images and video conferencing. As telemedicine and home hospitalization applications evolve, the resolution and functionality of these applications is expected to improve significantly. This will mean a higher demand for bandwidth and a continued need to maintain low latency. Therefore, communication networks must be robust and scalable to accommodate these future needs. On the hospital side, the communications infrastructure must be robust enough to manage multiple patients in parallel, ensuring that everyone receives the care they need without interruption. In addition, it must be able to scale in patient numbers as demand for telemedicine and home hospitalization services grows. Reliability and security are also critical considerations. Networks must be able to protect patient data privacy and ensure service continuity, even in situations of high demand or possible technical failures. In short, the telecommunications infrastructure must be flexible and ready to support technological innovations that will improve the quality of health care in the future.
Expected results	Hospitals are expected to significantly improve the quality of medical care. By allowing real-time access to patient data, healthcare professionals will be able to make more informed and accurate treatment decisions. In

[10] https://www.telemadrid.es/programas/telenoticias-1/El-Infanta-Leonor-se-convierte-en-un-hospital-sin-paredes-gracias-a-la-telemedicina-2-2466073383--20220705033327.html

Use Case	Home hospitalization (or approaches that mix home care and telematics) and the need for advanced telecommunications
	addition, patients will enjoy greater comfort with home-based care, reducing the need to travel to the hospital and improving their overall experience. Another expected result is a reduction in the costs associated with traditional hospitalization. Home hospitalization is a cheaper alternative, which can ease the financial burden on both patients and the health system. Together, these benefits will contribute to more efficient and effective care tailored to individual patient needs and supported by a robust and scalable telecommunications infrastructure. Hospitals that already have such solutions are expected to improve the quality and increase the functionalities of the services that make up the "hospital without walls" solution. In addition, from a technological point of view, it is anticipated that these services will be better able to scale to a larger number of patients or to different diseases, thereby optimizing care and expanding their reach.
Results obtained	

Use Case	Health Campus Connectivity: Hospital, Academy, and Companies
Users involved	Hospital health professionals who need to transmit information and data to local entities such as R&D departments, companies or educational institutions, public and private researchers, academics and students.
Challenges, Context, and Scope	The so-called "Oria Campus" Kadans is developing a center for companies in the life sciences and health sector, with special facilities such as laboratories, clean rooms, pilot plants, etc. The Ramón y Cajal Hospital, the medical school of the Autonomous University of Madrid, and other research centers and hospitals are located around the campus. The business centre is expected to form a dedicated health hub, and companies will collaborate with local research centres and hospitals. It is very foreseeable that this collaboration will require the transmission and exchange of large volumes of data in efficient and secure conditions between the companies, the hospital and the research groups. The challenge is to extend the connectivity that the system provides to the hospital to other agents and institutions in the environment. without compromising speed, efficiency and safety. In addition, the business center will have useful spaces for holding fairs, conferences and exhibitions that will require streaming communication.
(System requirements and communications technical considerations) (Latency requirements, bandwidth.)	Technologies that enable smooth transmission, with the highest quality of image and sound, and are easy to implement in operating rooms, medical facilities, meeting and conference rooms, classrooms, and public and private R&D labs.
Expected Results	Implementing a proper communication system that connects all actors in the university-company-hospital triangle • Increased public-private partnerships as healthcare companies need hospitals for proof-of-concept, validation, and clinical trials. • Improved technology transfer so that knowledge derived from clinical and research practice in hospitals and laboratories reaches the development departments of companies sooner (even in real time) to build viable prototypes and business models from them in line with the market. • Improvements in the quality of education, since teachers and students would have access to real cases of encounters between problems and solutions arising from day-to-day care and surgical practice, as well as communication between hospitals and companies' R&D departments, gaining access to training that is more practical and closer to clinical and economic reality.
Results obtained	An interconnected campus, with the highest possible standards of quality, speed and safety, at a cost equal to or lower than traditional technologies, will enhance relationships between agents generating knowledge, innovation, quality of care and wealth in the health sector.
Use Case	Fiber Optic Network Infrastructure for Digital Pathology in the Hospital
Users involved	Pathologists who analyze tissue samples using digital technologies. Researchers who benefit from efficient data sharing to accelerate the development of new treatments and therapies. Healthcare professionals who use accurate diagnoses to improve patient care. Patients who get more accurate and timely diagnoses. Medical students and residents who can access high-resolution digital

Use Case	Health Campus Connectivity: Hospital, Academy, and Companies
	images and clinical cases, improving their education and diagnostic skills.
Challenges, context, and scope	Implementing digital pathology faces several challenges, including the need for a robust, high-speed network infrastructure to handle large amounts of data generated by digital technologies. It is also crucial to ensure the security and confidentiality of patient data. The network must be able to manage multiple sessions in parallel, ensuring that multiple users and AI models can access and analyze data simultaneously without interruption. In today's context, digital pathology is transforming the field of medicine, offering significant advantages for both research and medical care. The scope of this project includes the implementation of fiber optic networks to support data traffic, enabling high-resolution digital images of tissue samples to be stored, analyzed, and shared quickly and efficiently.
System requirements and communications technical considerations (Latency requirements, bandwidth...)	Today, high-speed connectivity is essential to support the data traffic generated by digital pathology technologies. The latency should be low to ensure a smooth and uninterrupted experience for users. In addition, the network must be secure to protect the confidentiality of patient data. The hospital's communications infrastructure must be able to manage multiple users in parallel and scale to accommodate the future growth of the hospital's needs. The size of a compressed whole slide image is usually about 1-5 GB, and the display of a zoomed region can be about 50 MB. Thus, smooth interaction of individual zoom-in and zoom-out requires a good communication infrastructure, multiplying this need by parallel users either within the hospital or by telepathology services.[11]
Expected Results	The implementation of digital pathology is expected to significantly improve diagnostic accuracy, allowing tissue samples to be analyzed in greater detail and precision than traditional methods. This can lead to more accurate and timely diagnosis of diseases. In addition, research is expected to be more efficient, facilitating data sharing between researchers and accelerating the development of new treatments and therapies. Telepathology will allow pathologists to analyze tissue samples remotely, improving access to medical care in remote areas. Hospitals that already have such solutions are expected to improve the quality and functionality of digital pathology services, as well as scale these services to more patients or diseases from a technological point of view.
Results obtained	

[11] https://meridian.allenpress.com/aplm/article/143/2/222/64743/A-Practical-Guide-to-Whole-Slide-Imaging-A-White
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7522141/

Use Case	Optical fiber network infrastructure for telesurgery in the hospital
Users involved	Surgeons, who perform operations remotely using robots controlled from a remote console. Patients, especially those in rural areas or with limited access to specialists, benefit from high-quality surgical care. Medical students, both local and remote, are also key users, as they can witness operations or experiment with simulation models without endangering patients.
Challenges, context, and scope	Implementing telesurgery addresses several challenges, including the need for a robust, high-speed network infrastructure to handle large amounts of data generated by telesurgical technologies. It is also crucial to ensure the security and confidentiality of patient data. The network must be able to manage multiple sessions in parallel, ensuring that multiple users can access and operate simultaneously without interruption. Telesurgery has the potential to transform the field of medicine, offering significant benefits for both health care and the training of new professionals. The scope of this use case includes the implementation of fiber optic networks to support data traffic, enabling live viewing of operations, communication between surgeons, and handling of robotic equipment quickly and efficiently. The infrastructure must be scalable to accommodate the future growth of the hospital's needs, allowing for more patients and a greater variety of surgical procedures.
System requirements and communications technical considerations (Latency requirements, bandwidth...)	High-speed and stable connectivity is essential to support the data traffic generated by telesurgical technologies. Latency should be extremely low, ideally less than 20 milliseconds (ms), to ensure a smooth and seamless experience during operations. In addition, a minimum bandwidth of 1 Gbit/s (gigabit per second) is required to support the transmission of high-definition video and other medical data. The network must be secure to protect the confidentiality of patient data. As applications evolve, resolution and functionality are expected to improve, leading to higher bandwidth demands and a continued need for low latency. The hospital's communications infrastructure must be able to manage multiple users in parallel and scale to accommodate the future growth of the hospital's needs.
Expected results	The implementation of telesurgery is expected to significantly improve access to care in remote areas, allowing patients to receive high-quality surgical care without having to travel. In addition, operations are expected to be more accurate and safer, as telesurgical robots can perform more precise and delicate movements than human surgeons, reducing the risk of complications. Telesurgery also offers great opportunities for training new health professionals, allowing many students, both local and remote, to witness operations or experiments with simulation models without endangering patients.
Results obtained	

Use Case	Ultra High Definition (UHD) Videoconferencing and Multiconferencing in Healthcare
Users involved	Health professionals in hospitals and primary care practices, patients and caregivers in the home.

Use Case	Ultra High Definition (UHD) Videoconferencing and Multiconferencing in Healthcare
Challenges, context, and scope	Videoconferencing is now a tool of almost daily use in professional environments, and it is also becoming commonplace for the general population, both in its version of videoconferencing between two users and in its use in multi-conferencing sessions with several simultaneous users. In addition to their use for communication between professionals inside and outside hospitals, videoconferencing between patients and health professionals has also increased, especially in private healthcare, for both consultations and support in telemedicine services. However, the quality of these video calls is often limited in many cases by problems in network bandwidth and reliability, mainly at the LAN and WAN levels. restricting the use of image resolutions equal to or greater than high definition (image resolution greater than 1920x1080 pixels) and thus limiting image quality. Implementing fiber-to-the-device networks in the LAN/WAN environment paves the way for bringing the video standard used in video conferencing to the 4K resolution level. or Ultra High Definition 3840 x 2160 (8.3 megapixels) per frame), which is close to the concept of telepresence, significantly improving the perceived usefulness of video and multi-conferencing by providing a level of image detail and reliability that users are not used to. This will allow you to take advantage of improvements in devices, since many of the elements needed for multi-conferencing are already available on the desks of healthcare professionals (computers with hardware 4K encoding support, 4K monitors and cameras, mobile phones and tablets) In addition, patients and their caregivers have substantially improved their devices, including 4K support for several years on their mid-range and high-end smartphones, and even their homes now have smart TVs that are starting to have 4K resolution and can be used as video conference access terminals. However, using 4K technology in multiconferencing increases network traffic by at least 10 orders of magnitude over the current HD (1280x720) quality video conference. Therefore, five users connected in a multi-conference will require a minimum and sustained uplink and downlink bandwidth of 40 Mbit/s for the duration of the session. This significant increase in bandwidth requirements is the main barrier to its use in today's networks on a regular basis, as it requires advanced and robust telecommunications infrastructures. The increased capacity facilitated by fiber deployment will enable UDH multi-conferencing to be widely used as a standard communication tool between health professionals and patients outside the hospital, without fear of saturating communications networks during service delivery. with the following advantages: • Patients and caregivers' perception of the quality of remote care is improved if the image quality is closer to the concept of telepresence. • Easier to read when conveying content with text or graphics (presentations, etc.) • Improved health care professionals' ability to assess a situation or make a diagnosis based on user-generated video images (e.g. postoperative wound status, dermatology, general perception of the patient's condition) or interpret patient-generated images. Examples of application environments: • Communication between health professionals in hospitals.

Use Case	Ultra High Definition (UHD) Videoconferencing and Multiconferencing in Healthcare
	• Communication between health professionals in hospitals and professionals in primary care centers. • Communicating with patients and relatives. • Communicating with home and mobile patients in telemedicine and home hospitalization services. • Simultaneous communication in multi-conference events with patient and family groups at home or on the move for training and prevention. Improving video quality to UHD to bring videoconferencing closer to the concept of telepresence will result in greater videoconferencing efficiency and therefore, the benefits that the use of videoconferencing and multi-conferencing can bring to users and health care professionals will be maximized.
(System requirements and communications technical considerations) (Latency requirements, bandwidth.)	The application of video resolution in communications can multiply the bandwidth requirements. Thus, a multi-conferencing session with UHD quality implies that a user must be able to sustainably receive the data stream required to transmit UHD. For example, for 3840 x 2160 resolution at 25 frames per second and H265 encoding, these requirements would be between 10 Mbit/s and 20 Mbit/s depending on the type of content broadcast (people talking, screen sharing, such upload (upstream), and download (downstream) capacity will be required for each user participating in the conference call.

Expected results	• Improved resolution
	  ○ Typical current situation
	    ▪ SD quality, 640x480 resolution: 2Mbit/s
	    ▪ HD quality, 1280x720 resolution: 4 Mbit/s
	    ▪ FullHD quality, 1920x1080 resolution: 8 Mbit/s
	  ○ 4K Quality Utilization Situation
	    ▪ UltraHD quality, 3840x2160 resolution: minimum 10 Mbit/s, typical 15 Mbit/s.
	  ○ Current situation: latency of less than 300 milliseconds (roundtrip) to have a minimum perception of lag-free natural conversation, although values below 150 milliseconds are considered a more appropriate value.
	
	  ○ Estimated improvement: Jitter of less than 30 milliseconds to keep communications smooth, though less than 15 milliseconds are recommended.
	• Packet loss
	
	Although video streams using fairly robust encoding systems and in many cases using UDP protocol, average packet loss values of less than 0.1% are recommended.

Results obtained	

3. Smart Hospital POL Network Industry Overview

This section provides an overview of the POL network industry for smart hospitals, focusing on entities that significantly contribute to the digitalization and transformation of the healthcare system. Below are detailed fact sheets for each entity, highlighting relevant aspects such as the technology used, motivation and objectives, contribution to the digitalization of the sector, innovative solutions and applications, benefits and improvements achieved in healthcare and patient experience. These fact sheets are intended to provide a broad and detailed overview of the initiatives and organizations that are driving the move toward smart, connected hospitals.

Entity : Centre Tecnologico de Telecomunicacions de Catalunya (CTTC)

Typology: R&D in optical fiber network technologies and management

Motivation: As an R&D center, the motivation to participate in this project is the impetus in terms of research and innovation of fiber optic communications technologies, since it presents a totally new scenario for this type of network.

As a result, it is important to note that this position helps us to promote the development and adoption of standards internationally, specifically in the ETSI Fixed 5G study group.

Contribution to digitization

Digital Services and Solutions

1. Digital solutions and services offered by the distributor specifically for the digitization of hospitals

   Consulting on optical fiber technologies and networks

2. Features, benefits, and differentiators of these solutions and services.

   As a research center in this type of technology, our point of difference is based on different aspects, including:

   - Design and prototyping of custom communications systems, networks and network management software.
   - Enable access to testing and measurement of existing (or developing) solutions in a state-of-the-art laboratory environment.
   - Contribute to the definition of standards in international forums such as the European Telecommunications Standards Institute (ETSI), the Internet Engineering Task Force (IETF), or the Open Networking Foundation (ONF), among others

3. Success stories or projects where these solutions and services have been implemented with positive results

   The CTTC typically works on collaborative projects, participating in and leading international consortia. These projects emphasize the functionality and novelty of the solutions provided.

   In fact, the CTTC has a combination of technical and published background in the design and optimization of programmable optical hardware, as well as in the design of architectures and protocols/interfaces applied to network configuration and control. as demonstrated by the recently completed collaborative projects H2020 PASSION or H2020 INT5GENT.

   Similarly, CTTC has explored the applicability of artificial intelligence techniques and models

Entity : Centre Tecnologico de Telecomunicacions de Catalunya (CTTC)

for use in network operation with energy efficiency strategies in the H2020 B5G-OPEN and H2020 TERAFLOW projects; including the development of telemetry mechanisms for integration and experimental validation.

CTTC has also carried out research on transport networks, with a clear focus on point-to-point and point-to-multi-point communication technologies for metropolitan, trunk and long-distance segments. One example is the MetroHaul H2020 project.

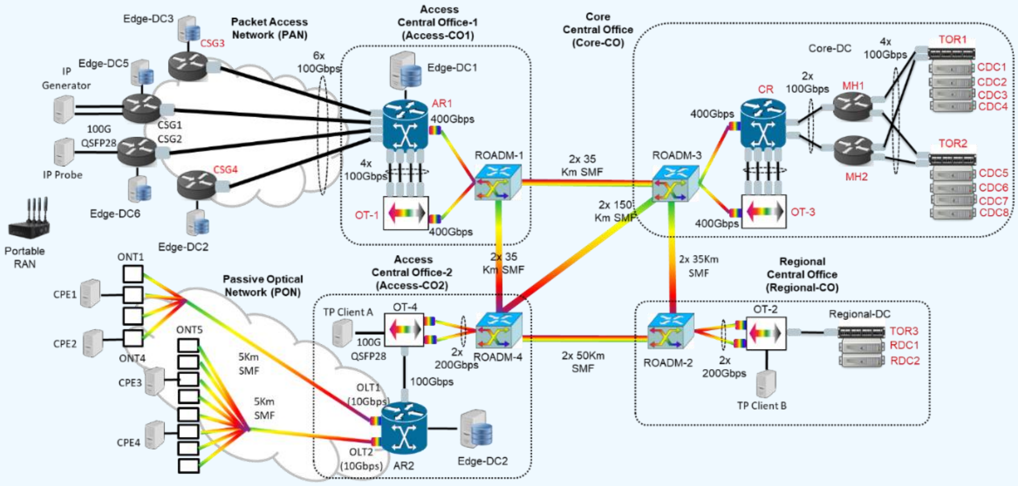
Given the growing need to integrate network resources with computing, it is important to highlight the contributions made in the framework of the Horizon Europe ACROSS project, which is developing a platform for deploying and managing end-to-end connectivity for future 6G networks.

In the area of network security, the CTTC contributed to H2020 Inspire-5GPLUS, which introduced a new automated management architecture for security services.

Current Infrastructures

4. Technological and communications infrastructures offered by the entity for the digitization of hospitals

The contribution of the CTTC to the digitization of hospitals comes in terms of the knowledge of the communication technologies to be deployed; studying the feasibility of these technologies for this precise use. However, CTTC has a specific infrastructure for experimental validation of optical networks. The ADRENALINE Testbed® is an open transport network combining optical and packet technology, integrating SDN/NFV paradigms with edge/core cloud infrastructure for 6G services. IoT/V2X and AI/ML. This infrastructure has been constantly evolving since its inception in 2002, and replicates operators' networks from an end-to-end and data center connectivity perspective. The following figure shows an overall diagram of the ADRENALINE Testbed®



5. Characteristics, specifications, and capabilities of these infrastructures.

ADRENALINE Testbed® covers access (PON), aggregation and trunk segments, and includes geographically dispersed data processing centers. As shown in the figure, the key elements are:

- An optical network controlled by SDN (photonic mesh), with 4 nodes and more than 600

Entity : Centre Tecnologico de Telecomunicacions de Catalunya (CTTC)
km of amplified links. Currently, all links in the mesh are based on C-band transmission, but one of them also supports L-band transmission • Packet optical nodes with pluggable optical transceivers, providing aggregate rates of 400 Gbit/s to carry traffic flows between access networks and central offices or data centers • SDN-enabled programmable S-BVT transceivers capable of transmitting multiple streams at variable data rate/up to 1 T bit/s. • A packet network (PAN) connected to the metro infrastructure with IP gateways for telephony cells (CSGS). • A PON tree consisting of distributed optical network terminals • A portable 5G radio access network platform (portable RAN) for testing and validating 5G uses cases. 6. Certifications and quality standards met by these infrastructures It is an experimental R&D infrastructure, so it is aligned with communications standards. As an R&D entity, the CTTC is certified according to the UNE 160002 standard. **Current applications** 7. Computer applications, tools and systems currently used for the digitization of hospitals As the CTTC is a communications technology R&D entity, it does not include application development but aims at information and communication technology development and innovation. 8. Brief description of the function and benefits of each application There are no specific applications for CTTC for digitizing hospitals. However, applications and systems of third parties and/or companies can be deployed and tested in ADRENALINE. **Benefits of digitization** 9. Highlight the expected benefits of digitizing hospitals, such as improved service quality, process optimization, data security and confidentiality, etc. The CTTC is a communications technology R&D center, so its activities are more in line with the following question. **Improvements to developing applications, infrastructures, etc** 10. Indicate the improvements in applications, infrastructures, and technologies being developed, briefly describing the benefits or improvement expected from this new development. For our part, we understand that the deployment of the cabling plant is simplified, as is the total number of equipment. There are several direct benefits to this: • Reducing network failures • Simplifying the operation and maintenance of the communications infrastructure • Reducing energy consumption • Easier and lighter cabling

Entity: Huawei Technologies Co., Ltd.

Typology: Global Solution Provider (ICT), Intelligent Devices and Infrastructures.

Motivation: Huawei is a leading global provider of information and communication technology (ICT) solutions, infrastructures, and smart devices. With solutions integrated in four key environments: telecom networks, IT, smart devices, and cloud services, it aims to bring digitalization to every person, home, and organization for a fully connected and intelligent world.

By collaborating with ecosystem partners, we create added value for our customers and work to empower people, enrich home lives, and inspire innovation in organizations of all kinds.

In Huawei, innovation is focused on the customer's needs. We invest heavily in research, focusing on the technological advances that drive the world forward.

In 2021, the EU launched its Digital Decade Strategy to accelerate Europe's green and industrial digital transformation. Huawei has its roots in Europe and provides extensive services in Europe.

The digitalization of the industry and in particular the healthcare sector, and the increasing application of AI processes, make the healthcare environment or smart hospital a campus environment that demands high-capacity services, real-time services, a multitude of users and connected devices, and very high availability. The solutions based on POL technology meet the basic requirements for developing the systems and needs of an Intelligent Hospital campus.

Contribution to digitization

Digital Services and Solutions

1. Digital solutions and services offered by the distributor specifically for the digitization of hospitals

   As a global ICT solution provider, we have a comprehensive solutions portfolio dedicated to developing the Intelligent Digitization of Hospitals.

   From computing, AI, cloud, wireless communications (5G/Wi-Fi), fixed communications, storage, IoT, etc.

   Focusing on campus connectivity, Huawei is a leader in the development and market share of POL technology by offering the industry's most advanced and robust solutions to support different redundancy and security requirements. The POL network can connect all required terminal devices in the healthcare network, such as DR, CT, MRI, PET, and SPECT in medical technology departments, PCS and IPTV, and other terminals in rooms.

2. Features, benefits, and differentiators of these solutions and services.

   POL solutions have several obvious advantages:

   1. Long service life of optical fiber-based physical media.

   2. The P2MP architecture saves a lot of cabling.

   3. Simplifies the network architecture and enables a single network for all campus services.

   4. Evolution to future services assured, simple, flexible and with low impact on cost and service availability.

   5. Highly robust, reliable and secure end-to-end solutions.

Ametic
LA VOZ DE LA INDUSTRIA DIGITAL

Entity: Huawei Technologies Co., Ltd.

6. Highly energy efficient, eco-friendly solution.
7. Easy operation, deployment and maintenance.
8. Efficient in investment and operation costs, estimated saving 30%.

3. Success stories or projects where these solutions and services have been implemented with positive results

Union Shenzhen Hospital

Founded in 1946, Union Shenzhen Hospital is the first grade A tertiary hospital in Shenzhen to pass the "New National Standard" revision. In 2019, the hospital was rebuilt with Huawei's all-optical solution, building an intelligent healthcare network with ultra-high bandwidth, unified transport, and high reliability and stability. POL is widely used in hospitals, improving the digital level and service efficiency of hospitals.

Hotel AVORIS

Ávoris specialises in holidays, leisure and business travel and is part of the prestigious and well-established Barceló Group. Huawei supports the XGSPON + Wi-Fi-6 solution to build high-bandwidth, easy-to-evolve, green and energy-efficient networks with intelligent operation and maintenance (O&M). Redundant OLT/GPON and XGS-PON ONT for high reliability. Up to 10.75 Gbps rate IoT and -Tri-band Access Points.

Current Infrastructures

4. Technological and communication infrastructures offered by the entity for the digitization of hospitals

Huawei is a leading global ICT solution provider, technology and industry leader in POL solutions, infrastructures, and smart devices. Integrated solutions in four key environments: telecom networks, IT, smart devices, and cloud services.

By collaborating with our ecosystem of technology partners, we create added value for our customers and develop the intelligent digitalization of the healthcare environment.

5. Characteristics, specifications, and capabilities of these infrastructures.

Equipment and services for developing smart campus connectivity projects.

6. Certifications and quality standards met by these infrastructures.

Huawei Technologies adheres to the highest quality standards, ISO 9001 for R&D&I management systems, ISO 27001 for information management and security, among others.

Current applications

7. Computer applications, tools and systems currently used for the digitization of hospitals.

The POL network provides Wi-Fi 5/6/7 Aps to provide high-speed Wi-Fi access, POTS service, IPTV/CATV service, CCTV service, and various interfaces to carry various services, such as CT, DR, and MRI devices. Provides Ethernet ports to support features such as desktop cloud office and dial-up Internet Protocol (IP) access.

8. Brief description of the features and benefits of each application.

Entity: Huawei Technologies Co., Ltd.

Service	Total image size	POL Read Time
CT	17,4G	The reading time is reduced to 1.5s, which is 10 times more than the traditional solution
MRI	16,3G	Reduced reading time to 1.2s, a 10-fold improvement over the traditional solution

Compared to traditional campus deployments based on UTP cabling, the POL network provides Gbps throughputs, very low latency, and allows very long-distance connectivity without active infrastructure. With POL technology, images can be read in seconds, saving doctors a lot of reading time. The intelligent hospital network usage POL solution supports high bandwidth, low latency, and easy O&M.

Benefits of digitization

9. Highlight the expected benefits of digitizing hospitals, such as improved service quality, process optimization, data security and confidentiality, etc.

Huawei POL network can provide different devices and solutions for different hospital scenarios.

Room	Specific requirements and service scenarios	Benefits
Query Room	1. Querying query information in real time (querying general data, small amount of data) 2. Office data, printer, phone	Compared to the traditional solution, 1 GB HD digital images take approximately 60 times longer from upload to aperture, from 5 minutes to 5 seconds.
Equipment Room	1.Remote Query and Query. 2. High video fluidity requirements	For a 1 GB CT group image, it takes only 0.4 seconds to load the image in standard mode, allowing non-perceptual reading.
Meeting Room	1. Streaming connectivity (4k video streaming) 2. Online meetings require a high level of clarity, and online live broadcasts require a high level of load.	The guaranteed bandwidth of the PON starts at 200 Mbit/s, the rate is higher than 1 Gbit/s, and the latency is lower than 10 milliseconds

10. Indicate the improvements in the applications, infrastructures, and technologies being developed, briefly describing the expected benefits or improvement of this new development.

NA

Entity: Polytechnic University of Madrid (UPM)

Typology: Public University

Motivation:

The Polytechnic University of Madrid (UPM), as a leading academic institution in technology and innovation, has a long history of projects related to digitalization and biomedical engineering. Throughout its history, the UPM has led efforts to integrate advanced technology into the healthcare sector, helping to develop pioneering solutions that improve both operational efficiency and the patient and professional experience.

In the area of digitalization, the UfM has been actively involved in national and international projects promoting the digital transformation of health systems, with its focus on interoperability. cybersecurity and the use of emerging technologies such as artificial intelligence and big data analytics. The UfM has been working on the design and development of technological tools to optimize hospital management, improve the quality of care and facilitate access to health services for the entire population.

On the other hand, in the field of biomedical engineering, the UPM has promoted innovative solutions for the diagnosis, treatment and follow-up of patients, integrating disciplines such as biomedical informatics, care robotics and connected medical devices. Close collaboration with hospitals, technology companies and research centers has enabled the UfM not only to train highly qualified professionals, but also to transfer knowledge and technology to the health system.

In this context, the UfM's participation in the AMETIC initiative on POL Networks for Smart Hospitals reinforces its commitment to transforming the healthcare sector. The UPM positions itself as a partner in integrating these highly efficient and sustainable networks into hospital infrastructure, supporting the creation of connected and safe environments that facilitate state-of-the-art healthcare.

Contribution to digitization

Digital Services and Solutions

1. Digital solutions and services offered by the distributor specifically for the digitization of hospitals

   The UPM offers various digital solutions and services aimed at digitizing hospitals, including through its HealthTech UPM initiative. This multidisciplinary platform seeks to bring academic expertise to health services, companies and technological innovations, with the aim of improving health care and well-being.

   UPM Health Tech's main areas of activity include:

   - Artificial Intelligence (AI): Application of AI and machine learning techniques for pattern detection, preventative diagnosis, and medical decision support. This includes merging clinical, molecular, and imaging data to develop image-based biomarkers using Deep Learning.
   - e-Health applications: development of digital solutions for patient tracking, integration of biomedical databases, and support in chronic disease management. This includes mHealth tools and IoT sensors to improve patient monitoring and care.
   - Robotics and Telesurgery: Implementation of robotic technologies for surgical and rehabilitation procedures, including low-cost robotics for rehabilitation and telesurgery, facilitating remote medical interventions and improving surgical accuracy.
   - Collaboration with Hospitals and Health Centers: UPM Health Tech maintains close relationships with health research and innovation centers, promoting the implementation of advanced technological developments in hospital settings.

Entity: Polytechnic University of Madrid (UPM)

Projects such as NEUROCENTRO CM and BigMedilytics are examples of such collaborations focused on improving the diagnosis and treatment of various pathologies.

These initiatives reflect the UfM's commitment to providing digital solutions that facilitate the transformation and modernization of hospitals, improving operational efficiency and the quality of healthcare.

2. Features, benefits, and differentiators of these solutions and services.

The UPM's digital solutions and services for digitalization in hospitals stand out for their innovation, positive impact on operational efficiency, and contribution to improving healthcare. The main features, benefits, and differentiating elements of these proposals are as follows:

Key features:

- **Interdisciplinarity: the solutions combine advanced knowledge in biomedical engineering, telecommunications, computer science, control and robotics, adapting to the specific needs of the hospital environment.**
- **Cutting-edge technology: Application of artificial intelligence (AI) for predictive analytics and early diagnosis. Using Big Data tools to integrate and analyze large volumes of clinical data. Implementation of robotics for assisted surgery and personalized rehabilitation.**
- **Patient-centric approach: Developing solutions to personalize care, such as IoT sensors and mobile apps that enable continuous, remote monitoring.**
- **Interoperable platforms: Solutions ensure interoperability with other hospital information systems (HIS, PACS, EMR), promoting a cohesive digital ecosystem.**

Benefits:

- Operational Efficiency:
    - Automation of administrative and clinical processes.
    - Reduce wait times and optimize workflow for clinicians and patients.
- Improving patient care:
    - Real-time access to relevant information for faster, more accurate, and more personalized clinical decisions.
    - Continuous monitoring improves the prevention and monitoring of chronic diseases.
- Treatment innovation:
    - Implementing AI algorithms and robotics for safer and more accurate interventions.
    - Using genomic and imaging analysis to personalize therapies.
- Cost savings:
    - Reduce redundancies in clinical and administrative processes.
    - Optimizing the use of hospital and energy resources.

Differentiators:

- Synergy with hospitals and research centres: UPM works directly with hospitals and research organisations to ensure solutions are tailored to the real demands of the industry.
- Experience in international projects: participation in initiatives such as

Entity: Polytechnic University of Madrid (UPM)

BigMedilytics which combines AI and Big Data to revolutionise healthcare across Europe.
- Technological robustness: Using advanced networks like POL to ensure the connectivity and scalability needed for smart hospitals.
- Commitment to sustainability: implementing energy efficient solutions, minimizing carbon footprint and material use.
- Education and training approach: development of programs to train hospital staff in the use of new technologies, ensuring a smooth transition to digitalization.

3. Success stories or projects where these solutions and services have been implemented with positive results

1. **Madrid Neurocenter**

   Description: A project funded by the Community of Madrid in which the UPM collaborates to develop advanced technologies for the diagnosis and treatment of neurological diseases.

   Results: Development of continuous monitoring systems for patients with neurological pathologies. Implementation of real-time brain signal analysis techniques.

2. **BigMedilytics**

   Description: European project in which the UfM collaborates to apply Big Data and advanced analytics to improve the healthcare system.

   Results: Diagnosis waiting times reduced through predictive analytics. Optimizing hospital management by integrating large-scale clinical data.

3. **AllerScreening**

   Description: European project to develop an innovative platform for early diagnosis of food allergies using optical technology, translating this technology into the clinical routine using a simple and efficient system.

   Results: Multiplex diagnostic kits and a Point-of-Care optical reader were developed for simultaneous detection of multiple allergens. Improved sensitivity and specificity in detecting allergens such as eggs and nuts, with fast test times and no need for labelled secondary antibodies.

4. **BIOPIELTEC-CM**

   Description: Research project to develop advanced technologies for manufacturing and optimizing human tissues, especially skin, using 3D bioprinting and tissue engineering techniques. The goal is to create dermal and epidermal equivalents with advanced biological and non-biological functionalities for clinical, pharmaceutical and cosmetic applications.

   Results: Development of 3D bioprinters specializing in skin manufacturing and creation of innovative biotins. Manufacture of dermal and epidermal equivalents with more complex and stable structures, including the incorporation of immune systems and structures such as hair follicles. Deployment of specific sensors to track these equivalents in animal models and potentially in patients.

5. **IMIDoc: Digital Health Tool for Implementing a Mixed Care Model (MAM) in Immune-mediated Inflammatory Diseases**

   Description:

   Within the framework of Project FIS PI22/00777, a digital health tool has been

Entity: Polytechnic University of Madrid (UPM)
developed to implement a Mixed Care Model (MAM) in the management of immune-mediated inflammatory diseases (IMID). The solution allows data and measurements reported by patients to be captured. (PROMs), encouraging self-management of health and enabling doctors to monitor these patients on an ongoing basis. This project, led by rheumatologists from the La Paz University Hospital in Madrid, has been supported by other reference hospitals such as Ramón y Cajal, Vall d'Hebron, Infanta Leonor and Bellvitge. **Results:** • Development and implementation of a digital solution for continuous IMID patient monitoring. • Promoting patients' self-management of health through accessible digital tools. • Better clinical follow-up thanks to the integration of PROMs into daily care practice. • Successful collaboration between hospitals to standardize care models for complex diseases. 6. **ToBrainHealth Personalized Intervention Model Based on XAI Data Analysis and Digital Phenotyping for Increasing Adherence and Promoting Brain Health** **Description:** This project addresses the scientific and technological challenge of preserving brain health in an aging population. Using a multidisciplinary approach combining biomedical engineering and neuroscience, the project develops a personalized intervention model based on data analysis using explainable artificial intelligence (XAI) and digital phenotyping. Collaboration between researchers in biomedical engineering, user experience, and neuroscience enables multi-domain technology interventions to be designed in conjunction with clinical teams specializing in brain health and resilience. **Results:** • Creating a model for personalized intervention to promote brain health and adherence to preventive treatments. • Development of XAI-based tools that provide interpretability in brain health data analysis. • Improved user experience in technology interventions for older populations. • Promoting brain resilience through personalized, evidence-based interventions tailored to individual needs. 7. **BACTEREMIA: Developing a National Bacteremia Database and Automated, Multi-Platform e-Health App to Improve Antimicrobial Prescribing** **Description:** This project aims to create an e-health tool to improve the prescribing of antimicrobials in cases of bacteremia, tailored to the regional microbial ecosystem and the specific needs of each patient. The constantly updated national bacteremia database feeds a multi-platform app designed to assist physicians and PROA (Antibiotic Optimization Programs) teams in selecting empirical treatments based on geographic and clinical information. **Results:**

Entity: Polytechnic University of Madrid (UPM)

- Development of a national bacteremia database capable of real-time reflection of microbial trends in different regions and hospitals.
- Creation of an e-health app that assists in empirical antimicrobial prescribing, optimizing treatments and reducing bacterial resistance.
- Improve the adequacy of antimicrobial prescriptions, contributing to safer and more personalized clinical practice.
- Support the PROA teams in creating antibiotic policies tailored to local needs.

Current Infrastructures

4. Technological and communications infrastructures offered by the entity for the digitization of hospitals

The Polytechnic University of Madrid (UPM) has a wide range of advanced infrastructures aimed at facilitating the digitalization of hospitals, including:

- **Advanced Communications Networks: Passive Optical LAN (POL) networks and 5G/F5G technologies to connect hospital services with high capacity, low latency, and energy efficiency.**
- **Data Centers and Cloud Solutions: Massive storage and processing of medical data with centralized systems that enable interoperability between hospitals and medical devices.**
- **IoT systems: sensors, wearables, and real-time monitoring platforms that enable continuous patient tracking.**
- **Hospital Robotics: robotic devices for operating rooms and personalized rehabilitation.**
- **Analytics and Big Data Platforms: Predictive analytics capabilities, and clinical and management decision support.**
- **Cybersecurity and Technology Resilience: Infrastructures that ensure the protection of sensitive data and business continuity in critical environments.**
- **Labs and Innovation Centers: spaces like UPM HealthTech that connect research, innovation and practical applications in smart hospitals.**

5. Characteristics, specifications, and capabilities of these infrastructures.

- **Communications Networks:**
  - High capacity (transmission of multiple terabytes of data).
  - Low latency to support critical applications such as assisted surgery and real-time analysis.
  - Scalability to serve large and small hospitals.
- **Data Centers:**
  - Support for Big Data, including medical imaging and genomic data processing.
  - Integrate with hybrid cloud services to ensure availability and secure access from any location.
- **IoT and Wearables:**
  - Advanced biometric sensors and handheld devices to collect real-time data.
  - Ability to integrate with hospital platforms (HIS, EMR).
- **Hospital Robotics:**
  - Precision in surgical care and rehabilitation.

Entity: Polytechnic University of Madrid (UPM)

- Personalization based on patient data.
- **Predictive Analytics:**
  - Machine learning and artificial intelligence algorithms.
  - Early detection of complications and medical decision support.
- **Cybersecurity:**
  - Protect against cyber-attacks using advanced encryption techniques and constant monitoring.
  - Resilience to disasters with data recovery systems.

6. Certifications and quality standards met by these infrastructures

- **Cybersecurity Regulations:**
  - Compliance with ISO/IEC 27001 (Information Security Management).
  - Data protection under the EU General Data Protection Regulation (GDPR).
- **Digital Health Standards:**
  - Implementation of international standards such as HL7 and FHIR for system interoperability.
  - Application of specific standards for medical imaging (DICOM) and hospital information systems.
- **Energy Efficiency and Sustainability:**
  - Design according to EU-defined energy efficiency principles.
  - Environmental compliance for technology infrastructures.
- **Quality in Biomedical Engineering:**
  - Medical device standards covered by Regulation (EU) 2017/745.
  - Certification in biomedical design and development processes supported by specific ISO standards (ISO 13485).

Current applications

7. Computer applications, tools and systems currently used for the digitization of hospitals

The Polytechnic University of Madrid (UPM), through its digital health initiatives and collaboration with hospitals, uses and develops various applications, tools and IT systems for the digital transformation of hospitals. These include:

- **HIS (Hospital Information System): Integrated hospital management systems.**
- **EMR (Electronic Medical Records): Centralized digital medical records.**
- **PACS (Picture Archiving and Communication System): storing and retrieving medical images.**
- **LIS (Laboratory Information System): data management in clinical laboratories.**
- **IoT sensors and wearables: Remote patient monitoring.**
- **AI and Big Data Platforms: Advanced algorithms for clinical data analysis.**
- **Telemedicine and Digital Health Platforms: platforms for remote consultation and patient follow-up.**
- **POL networks: communications infrastructure for smart hospitals.**

8. Brief description of the function and benefits of each application

1. HIS (Hospital Information System)

Function: Integrates all administrative, clinical, and financial processes of a hospital.

Entity: Polytechnic University of Madrid (UPM)

Benefits: Improves operational management, optimizes resources, and reduces administrative errors.

2. EMR (Electronic Medical Records)

Function: Stores and manage electronic medical records of patients.
Benefits: Fast and secure access to clinical information, promoting continuity of care.

3. PACS (Picture Archiving and Communication System)

Function: Manages medical images such as X-rays, CT scans, and MRIs.
Benefits: Digitizes and centralizes image storage, reducing the need for physical media.

4. LIS (Laboratory Information System)

Function: Automates the management of samples and laboratory results.
Benefits: Reduces processing times and ensures traceability of samples and data.

5. IoT sensors and wearables

Function: monitor patients' vital signs and medical parameters in real time.
Benefits: allow continuous and remote monitoring, facilitating preventive and personalized care.

6. AI and Big Data Platforms

Function: Analyze large volumes of clinical data to extract patterns and make predictions.
Benefits: diagnostic support, risk identification and treatment optimization.

7. Telemedicine and Digital Health Platforms

Function: They provide remote medical consultations through video calls and access to medical records.
Benefits: Increased accessibility to medical services, especially in remote areas.

8. POL Networks (Passive Optical LAN)

Function: Optical fiber infrastructure for interconnecting hospital systems and devices.
Benefits: High transmission rate, low latency, and support for multiple real-time services.

Benefits of digitization

9. Highlight the expected benefits of digitizing hospitals, such as improved service quality, process optimization, data security and confidentiality, etc.

- **More accurate diagnostics:**
    - **AllerScreening - Development of an early diagnosis system for food allergies using optical technology capable of detecting multiple allergens simultaneously. This improves the sensitivity and specificity of detecting allergens such as eggs and nuts, integrating this solution into the hospital's clinical routine.**
    - **BigMedilytics – Using artificial intelligence (AI) and data analytics to identify medical patterns and anticipate clinical complications.**
    - **BACTEREMIA: Create a national database to optimize the selection of antimicrobial treatments, adapting them to the characteristics of the regional microbial ecosystem and improving clinical response in serious**

Entity: Polytechnic University of Madrid (UPM)
infections.

Entity: Polytechnic University of Madrid (UPM)

infections.

- **Personalized attention:**
  - **BIOPIELTEC-CM: Application of advanced 3D bioprinting technologies to manufacture personalized human tissues, such as skin, with direct applications in reconstructive surgery, pharmaceutical testing and burn treatment.**
  - **ToBrainHealth – Personalized interventions based on explainable AI (XAI) data analysis and digital phenotyping aimed at preserving brain health in aging populations.**
- **Greater information availability: The interoperable systems developed by UPM ensure fast and secure access to critical clinical data, facilitating critical decision-making.**

2. Optimization of hospital processes

- **Task automation: Technology infrastructures such as POL networks and predictive analytics platforms, designed by the UPM, automate administrative and clinical processes, such as scheduling diagnostic tests and tracking treatments.**
- **Reduced waiting times:**
  - **AllerScreening – The integration of a Point-of-Care reader enables rapid diagnostics, significantly reducing analysis times and improving patient experience.**
- **Efficient resource management:**
  - **BigMedilytics - Optimizes clinical resource allocation through predictive analytics.**
  - **BIOPIELTEC-CM: Custom fabric manufacturing in hospitals reduces dependence on external laboratories and improves the availability of materials for advanced treatments.**

3. Increased data security and confidentiality

- **Advanced Cybersecurity: The platforms developed by the UPM include advanced encryption and monitoring techniques to prevent cyberattacks.**
- **Access traceability: Projects such as BIOPIELTEC-CM ensure detailed tracking through sensors that monitor processes and treatments in real time.**

4. Greater accessibility to health services

- **Telemedicine and Remote Consultations:**
  - **IMIDoc: digital tool for remote monitoring of patients with immune-mediated inflammatory diseases, promoting health self-management and ensuring continuous clinical follow-up.**
  - UPM-designed IoT solutions and POL networks ensure connectivity in rural areas and areas with limited access to medical services.

5. Reducing Costs

- **Savings on physical infrastructure:**
  - **AllerScreening – Reduce reliance on external labs by integrating diagnostics**

Entity: Polytechnic University of Madrid (UPM)

into a single Point-of-Care system.

- **BIOPIELTEC-CM: Manufacturing custom fabrics in hospitals minimizes the costs associated with importing or manufacturing dermal equivalents externally.**
- **IMIDoc: Reducing unnecessary face-to-face visits by implementing a mixed care model.**

6. Encouraging Innovation, Sustainability and Learning

- **Driving medical research:**
  - **BIOPIELTEC-CM: 3D bioprinting innovation to create custom fabrics for clinical, pharmaceutical and cosmetic applications.**
  - **ToBrainHealth – Promotes brain resilience through data analysis and personalized strategies.**
  - **BACTEREMIA: improves research capacity in serious infections by integrating up-to-date geographic and clinical data.**
- **Environmental sustainability:**
  - **AllerScreening – Use of reusable kits and simplified technology to reduce waste in diagnostic processes.**
  - POL networks are designed for hospitals, optimizing energy consumption and reducing carbon footprint.
- **Clinical Education and Training:**
  - UfM projects include training components to train health professionals in the use of digital tools and innovative models, improving their ability to take advantage of advanced technologies in clinical practice.
  - Initiatives such as IMIDoc and BACTEREMIA promote the adoption of new technologies through workshops and practical guides for clinical and hospital teams.

Improvements to developing applications, infrastructures, etc

10. Indicate the improvements in applications, infrastructures, and technologies being developed, briefly describing the benefits or improvement expected from this new development.

The Polytechnic University of Madrid (UPM) continues to lead innovative developments in digital health and biomedical technology, with projects aiming to transform the hospital sector. Ongoing improvements, along with expected benefits, are highlighted below:

1. Development of Advanced Optical Networks

- **Project: Expanding the capabilities of Passive Optical LAN (POL) Networks for Smart Hospitals.**
- **Expected benefit:**
  - Increased transmission capacity to support increased medical data (Big Data, IoT) traffic.

Entity: Polytechnic University of Madrid (UPM)

- Reduced latency, key to services like telemedicine and robot-assisted surgery.
- Increased sustainability through lower energy consumption and more durable materials.

2. New Artificial Intelligence (AI) Platforms

- **Project: Implementation of advanced Machine Learning and Deep Learning tools for complex clinical data analysis.**
- **Expected benefit:**
  - Early and more accurate detection of pathologies by integrating genomic data, medical images, and clinical records.
  - Optimize personalized treatments based on accurate predictions and real-time analysis.

3. Innovation in 3D Bioprinting and Tissue Engineering

- **Project: Expansion of the capabilities of the BIOPIELTEC-CM project, integrating new fabric types and functionalities.**
- **Expected benefit:**
  - Production of more complex customized tissues, including vascular equivalents and skin with functional capillary structures.
  - Applications in reconstructive surgery, pharmaceutical trials, and advanced treatments for chronic diseases.

4. IoT sensors and remote monitoring systems

- **Project: Design of next-generation wearable devices and implantable sensors for real-time monitoring of vital parameters.**
- **Expected benefit:**
  - Improved home care for chronic patients by providing automatic alerts for critical deviations.
  - Increased accuracy in monitoring hospitalized patients, reducing human error.

5. Built-in platforms for fast and accurate diagnosis

- **Project: Optimizing the AllerScreening system to include more allergens and other key biomarkers.**
- **Expected benefit:**
  - Faster and more accessible diagnostics in clinical settings, reducing the burden on hospital labs.
  - Expansion of use to rural areas through low-cost portable systems.

6. Cybersecurity Technologies in Digital Health

- **Project: Development of advanced AI and blockchain-based security protocols to protect medical data.**
- **Expected benefit:**
  - Greater protection against cyber-attacks by ensuring the integrity and

Entity: Polytechnic University of Madrid (UPM)
confidentiality of electronic records. ○ Automated audits to ensure compliance and prevent unauthorized access. **7. New Tools for Medical Image Analysis** • **Project: Creation of software specializing in automatic AI-based medical image analysis.** • **Expected benefit:** ○ Increased speed and accuracy in interpreting X-rays, CT scans, and MRIs. ○ Support clinical decision making with advanced visual tools. **8. Interoperability ecosystems** • **Project: Enhancement of platforms to integrate various hospital systems (HIS, EMR, PACS).** • **Expected benefit:** ○ Eliminating data silos, facilitating continuity of care between different levels and locations. ○ Greater efficiency in hospital management due to the centralization of information.

Entity : Vicomtech Center for Visual Interaction and Communications Technologies (VIC)

Typology: Private non-profit technology center specializing in Artificial Intelligence, Visual Computing and Interaction.

Motivation: Since its foundation, Vicomtech has worked on two important aspects of this project: communications networks and the application of ICT to the health sector.

On the one hand, thanks to telecommunications networks, including the latest advances in 5G technologies, such as network virtualization and elements such as MEC (Multi-access Edge Computing), Vicomtech is currently investigating end-to-end solutions for the distribution of multimedia content in any environment through dynamic network management, Adaptive low-latency streaming technologies and adding intelligent control to the session to maximize user experience and reduce costs for content providers. The main motivation for this department's participation is related to optimizing communications and supporting digital media solutions through software configuration and management of virtual communications networks.

In addition, the Department of Digital Health and Biomedical Technologies is engaged in research and development of technologies for the biohealth field. The solutions developed are applied in areas such as healthy living and aging, digital health solutions, medical/in vitro devices with digital components, or accelerating biomedical research and personalized medicine. The main motivation is to develop future-oriented biotechnology solutions for hospitals and healthcare, taking advantage of the potential of POL fibre-optic communications networks. These solutions include telemedicine, decision support, and other care, management, or research processes.

Contribution to digitization

Digital Services and Solutions

1. Digital solutions and services offered by the distributor specifically for the digitization of hospitals

   The Department of Digital Health and Biomedical Technologies is engaged in research and development of technologies for the biohealth field, including artificial intelligence for prediction or classification into various diseases or processes, biomedical image analysis, digital diagnostics, decision support systems, Big Data for preventive and precision medicine, simulation, and human-device interaction technologies. These developments are carried out in close collaboration with public and private health and socio-health systems and services, pharmaceutical and biotechnology companies, technology companies in the sector, and the biomedical and research sectors.

2. Features, benefits, and differentiators of these solutions and services.

   - Digital Health: clinical decision support systems; predictive models based on real-world data; AI-based remote monitoring solutions; knowledge/evidence modelling.
   - Healthy Living and Aging: AI for self-management and health coaching; Big Data and AI for personalized prevention; social-health solutions.
   - Precision medicine and new therapies: molecular biomarkers; AI for precision medicine and clinical trials; data analytics for pharma/biotech.
   - Image analysis and Deep Learning: digital biobanks; image biomarkers; deep phenotyping; image synthesis and restoration; pathology and cognitive radiology.
   - Biomedical devices: 3D bioprinting; biomedical simulation; surgery and image-guided robotics, VR/AR in the operating room.
   - Big Data: RWD capture platforms; healthcare data spaces; data preparation and harmonization; synthetic data generation.

Entity : Vicomtech Center for Visual Interaction and Communications Technologies (VIC)

3. Success stories or projects where these solutions and services have been implemented with positive results
   - Understand risk factors and develop AI models for screening and early diagnosis of lung cancer with multiple types of data - LUCIA (Horizon Europe).
   - Development of an intelligent, multifunctional, cost-effective, 3D printed dressing for inflammation and infection control in chronic wounds - ForceRepair (Horizon Europe).
   - Federation of Real-World Data (RWD) sources for improved diagnosis and risk assessment of cardiovascular disease - CVDLink (Horizon Europe).
   - Synthetic generation of reliable, high-quality haematological data in federated frameworks for virtual patient modelling - SYNTHEMA (Horizon Europe).
   - AI-based digital tools for image processing applicable to different processes and pathologies - Pathflow (project No. 1 in AEI of its call).
   - Support techniques for intraoperative 4D bioprinting of customized precision grafts - Bio4cure (regional basic research project).
   - System for close monitoring of the comprehensive status of the elderly for early detection and intervention - ORKESTA (industrial research project).
   - Development and validation of the European Cancer Survivor Smart Card-CSSC prototype (HADEA Tender, EC).
   - System to help detect various pathologies with image analysis and AI- CADIA (CPI, Servizo Galego de Saúde).

Current Infrastructures

4. Technological and communications infrastructures offered by the entity for the digitization of hospitals

   Advanced mobile technologies are Vicomtech's line of research, with a special focus on 5G & beyond technologies and their application in verticals such as healthcare. In particular, Vicomtech is an expert in the following areas: software-defined networking (SDN, NFV, radio and network slicing, network orchestration); virtualization technologies both at the edge and in the cloud; multi-layer monitoring systems; APIs for configuring and operating virtualized communications network resources; technologies for immersive data visualization.

   Vicomtech has an advanced laboratory used to carry out R&D projects and replicate real ecosystems for the validation of solutions. This laboratory is also used for other tasks such as measuring and verifying prototypes, commercial equipment, interoperability testing, etc. This private network includes all segments of the network for end-to-end experimentation for static and mobile systems.

5. Characteristics, specifications, and capabilities of these infrastructures.

   San Sebastian's 5G experimentation network provides a test area for indoor and outdoor experiments on 5G technologies and infrastructures (around Vicomtech facilities) to support different verticals and their use cases.

6. Certifications and quality standards met by these infrastructures

   Vicomtech is certified to UNE166002 and ISO 9001 for R&D&i management systems, ISO 27001 for information management and security, and ISO 22301 for business continuity management.

Entity : Vicomtech Center for Visual Interaction and Communications Technologies (VIC)

Current applications

7. Computer applications, tools and systems currently used for the digitization of hospitals

In 2007, Vicomtech began an incremental software asset development strategy based primarily on the development of internal SDKs to identify and protect the center's contract signing background; facilitate incremental development and speed implementation of area technology roadmaps by reusing code; reduce training time for new recruits; and standardize programming guidelines (documentation, validation) internally. These assets are the software expression of the general know-how of a center's technology, being incremental and independent of the specific projects that use them. They all include version control, a summary of features by version and briefing materials, and a comprehensive development environment that makes them easy to use and encapsulate in specific projects.

8. Brief description of the function and benefits of each application

The Digital Health and Biomedical Technologies department has the following software assets related to this project:

BioPrint - Easy-to-use software tools that optimize 3D printing results for low shrinkage materials used in the biohealth world.

Adilib: software library for the development of highly versatile chatbots and chat assistants.

MIST: software tools for rapid prototyping and development of medical image analysis and visualization applications.

Benefits of digitization

9. Highlight the expected benefits of digitizing hospitals, such as improved service quality, process optimization, data security and confidentiality, etc.

Vicomtech is very interested in participating in the validation of some of the proposed use cases under this initiative. Specifically, the use case for hospital teleradiology has been proposed, which allows electronic transmission of radiological images - CT scans, X-rays, MRIs, etc. from one location to another for the primary purpose of interpreting or querying a diagnosis. When the patient load of radiology exceeds a medical facility's ability to read images in an appropriate amount of time, hospitals may contact radiologists elsewhere for support. They can also take advantage of teleradiology to reach radiologists in distant time zones to meet radiology needs outside of business hours, such as night hours in emergency and emergency departments. This is especially useful for hospitals and clinics in rural areas.

Shipment size is expected to continue to grow in the coming years, requiring more storage capacity and bandwidth. Given that rapid and accurate diagnosis of patients is a key element in improving health services and given the current volume of use of teleradiology, the expected effect of the introduction of fibre for teleradiology needs will have the most significant effect on improving the capabilities of digital hospitals.

Improvements to developing applications, infrastructures, etc

10. Indicate the improvements in applications, infrastructures, and technologies being developed, briefly describing the benefits or improvement expected from this new development.

Entity : Vicomtech Center for Visual Interaction and Communications Technologies (VIC)
As indicated above, the Digital Health and Biomedical Technologies department's main motivation is to develop future-oriented biotechnology solutions for hospitals and healthcare, taking advantage of the potential of POL fibre-optic communications networks. These new communications networks are expected to address today's research challenges. • Digital Health: clinical decision support systems; predictive models based on real-world data; AI-based remote monitoring solutions; knowledge/evidence modelling. • Precision medicine and new therapies: molecular biomarkers; AI for precision medicine and clinical trials; data analytics for pharma/biotech • Image analysis and Deep Learning: Digital biobanks; image biomarkers; deep phenotyping; image synthesis and restoration; pathology and cognitive radiology. • Biomedical devices: 3D bioprinting; biomedical simulation; surgery and image-guided robotics, VR/AR in the operating room. • Big Data: RWD capture platforms; healthcare data spaces; data preparation and harmonization; synthetic data generation.

Entity : Kadans Science Partner

Typology: Infrastructures for Enterprise R&D and Public-Private Collaboration

Motivation: we create and manage centers for companies in knowledge-intensive environments such as healthcare campuses, encourage collaboration and transfer between hospitals and academia, and need a connection network to support the increase in data traffic in the future, not only within the hospital but also in its relationship with other buildings and institutions such as surrounding companies or educational institutions.

Contribution to digitization

Digital Solutions and Services

1. Digital solutions and services offered by the distributor specifically for the digitization of hospitals

   We want to offer unique spaces for the development of business activities linked to the hospital and therefore equipped with connectivity systems. equivalent to those that will be provided in hospitals so that this aspect of the infrastructure does not constitute a barrier to collaboration. We want to offer unique spaces for the development of business activities linked to the hospital and therefore equipped with connectivity systems. equivalent to those that will be provided in hospitals so that this aspect of the infrastructure does not constitute a barrier to collaboration.

2. Features, benefits, and differentiators of these solutions and services.

   We hope that the connected hospital will operate on a campus with other research, industrial, institutional, academic, etc. actors connected with the same level of efficiency and capacity.

3. Success stories or projects where these solutions and services have been implemented with positive results

   We are confident that the Oria Campus, in the vicinity of the Ramon y Cajal Hospital and the UAM School of Medicine, will be the first experience of this kind.

Current Infrastructures

4. Technological and communications infrastructures offered by the entity for the digitization of hospitals

   We can provide a center for technological companies and startups working with the hospital's groups and services, connected at the same level of capacity and efficiency as the hospital.

5. Characteristics, specifications, and capabilities of these infrastructures.

   Infrastructure to house laboratories, pilot plants, clean rooms, and any type of research or innovation facility that will be related to the hospital's research or healthcare processes.

6. Certifications and quality standards met by these infrastructures

   Environmental Breeam Certified.

Current applications

7. Computer applications, tools and systems currently used for the digitization of hospitals

   To be determined.

Entity : Kadans Science Partner
8. Brief description of the function and benefits of each application To be determined. **Benefits of digitization** 9. Highlight the expected benefits of digitizing hospitals, such as improved service quality, process optimization, data security and confidentiality, etc. Improvements in technology transfer processes, relations with the health industry, scientific, clinical and epidemiological research. The hospital will also be connected to the external industrial fabric with which it collaborates, thus improving and accelerating the processes by which business innovation in the health sector will reach patients and health professionals for better performance of their duties and higher quality of care (diagnosis, prognosis, therapy, etc.) Improvements in developing applications, infrastructures, etc. 10. Indicate the improvements in applications, infrastructures, and technologies being developed, briefly describing the benefits or improvement expected from this new development. We are in the process of building the infrastructure that will house the laboratories and defining the internal data network that should be similar to and connected to the hospital.

Entity : Meditecs
Typology: SME **Motivation: Drive the digitization and efficiency of next-generation hospitals by providing best-in-class data interoperability and system integration solutions.**

Contribution to digitization
Digital Services and Solutions

1. Digital solutions and services offered by the distributor specifically for the digitization of hospitals
   Meditecs works in Digital Health through the application of Information Technology to provide interoperability and system integration solutions.
   Meditecs solutions include: medical devices (diagnostic imaging, laboratory, patient monitoring, etc.), electromedical equipment, HCE and practice management systems, RIS and PACS, medical cloud platforms, and any other healthcare system or data source.

   Digital Technology Skills:
   - Cybersecurity (healthcare).
   - Health data spaces.
   - Interoperability.
   - Data integration.

2. Features, benefits, and differentiators of these solutions and services.
   By implementing solutions based on its own technology, MT Smart Connect, Meditecs makes it possible to approach any interoperability project regardless of the technologies or standards: HL7 V2.X, ASTM E1381, DICOM, HL7 FHIR, IHE Profiles...

3. Success stories or projects where these solutions and services have been implemented with positive results
   Scenario 1: Enhancing teleradiology services with advanced integration solutions. Using DICOM and HL7 standards and web-based communications, the customer management system (Agfa AHEI: PACS and RIS) was effectively integrated with multiple hospital information systems. such as Sectra MEI and PACS (Sweden), GE Collaboration Tools (Sweden), Soliton RIS (UK), Wellbeing CRIS (UK), Philips PACS, GE PACS, Siemens PACS.

   Scenario 2: Improving diabetes care by integrating cloud-based blood glucose data. The solution leverages industry-standard technologies such as OAuth and RESTful APIs to ensure secure communication between the cloud platform and HCE systems in hospitals and regions. The solution adheres to HL7 and FHIR standards, ensuring reliable and interoperable data transfer. The success of this initial project has resulted in continued deployments in hospitals in Spain, Belgium, the Netherlands, Italy and the United Kingdom.

   Scenario 3: Implementation of a Hospital Integration Infrastructure including:
   - Vendor integration: development of HL7 FHIR APIs for outsourcing outpatient consultations, radiological testing, and other testing through third-party vendors, including services such as querying assigned requests, updating appointments, and sending reports.
   - Integrations with clients: development of the integration circuits necessary to send patient-related care information from the mutuals with which the hospital collaborates, through various integration mechanisms, especially the HL7 FHIR

Entity : Meditecs

standard, including services such as admissions, tracking or sending reports.

Current Infrastructures

4. Technological and communications infrastructures offered by the entity for the digitization of hospitals
   MT Smart Connect - an integration engine.
   At the core of MT Smart Connect is Mirth Connect, a reliable and trusted integration engine by NextGen Healthcare, enhanced by more than a decade of experience in healthcare system integration and a proven integration methodology.
   Building on Mirth Connect's strong foundation and enhanced with advanced features, MT Smart Connect offers a smart approach to integrating healthcare systems.
   With more than 10 years of experience, MT Smart Connect simplifies the exchange of health data. Our solution reduces costs and accelerates deployment. Works with any system, standard or technology, thanks to its flexible design.

5. Characteristics, specifications, and capabilities of these infrastructures.
   Features:
   Advanced Messaging Management: snooped for high-volume messaging from multiple systems, offering specific configurations for each system.
   Semantic and Syntactic Validation: Verifies incoming messages by evaluating both their structural format and content, ensuring consistency and compliance with established standards.
   Repeated Message Control: Detects and manages duplicate or repeated messages, even if the identifiers differ, so your integration is not affected.
   Delayed Message Management: Delayed messages can be problematic. MT Smart Connect intelligently detects and manages lagging messages.
   Message Sequencing: Disorganized receiving of messages can distort data processing. Keep everything in order with timed processing windows.
   Managing Receipt Acknowledgments: You do not need to handle confirmation messages. Easily configure adjusted acknowledgments for each integrated system.
   Retry Policies: Defines retry strategies in the event of one-off system or network failures to ensure smooth operations.

6. Certifications and quality standards met by these infrastructures
   ISO 9001
   ISO 14001
   ISO 27001
   ENS (2024)

Current applications

7. Computer applications, tools and systems currently used for the digitization of hospitals
   Health interoperability refers to the ability of different technological systems and devices to exchange, interpret, and use data in a coordinated and efficient manner.
   Health interoperability enables the development and use of a wide range of digital health systems, applications and tools, including:
   1. Electronic Medical Records (EHR) management systems.
   2. HIS, LIS, RIS, and PACS.
   3. Telemedicine Platforms, Medical Cloud Platforms
   4. Electromedical equipment.

Entity : Meditecs

5. Medical devices (diagnostic imaging, laboratory, patient monitoring, etc.)
6. Teleradiology, including AI solutions.
7. Digital pathology, including AI solutions.

8. Brief description of the function and benefits of each application
Health data interoperability in any digital health application plays a crucial role. Ensuring high-quality continuous healthcare by making patient data accessible and understandable across multiple systems and platforms is critical.
Interoperability of health information systems is essential to achieving quality digital health by increasing the efficiency, effectiveness and accessibility of health services.

Benefits of digitization

9. Highlight the expected benefits of digitizing hospitals, such as improved service quality, process optimization, data security and confidentiality, etc.
Hospital challenges that we solve through Meditecs technology:
   1. Integrations of digital health systems and applications and medical devices.
   2. Processing and storing large volumes of data and images.
   3. Critical Integrations: Ensure reliable data and image sharing for urgent cases.
   4. Compliance with security standards, especially for cloud scenarios with data sources outside of hospital networks.
   5. Heterogeneity of systems, protocols, and languages: adapt to different protocols, such as DICOM, HL7, and FHIR, adapted to different organizational needs.
   6. Advanced monitoring provides a preventive support service capable of detecting incidents in early stages and being able to act before they escalate and paralyze hospital systems.
   7. Workflow complexity.
   8. Optimizing cost-effectiveness.

Improvements to developing applications, infrastructures, etc

10. Indicate the improvements in applications, infrastructures, and technologies being developed, briefly describing the benefits or improvement expected from this new development.
New messaging broker for all systems involved in Digital Pathology: scanners, IMS viewers, AI image analysis tools, EHR, HIS, LIS, PACS, VNA, etc.

Agency: Spanish Association for Standardization (UNE)

Typology: Private non-profit association. National Standards Agency.

Motivation: Standards ensure fair competition and provide an incentive to improve quality. Companies benefit from their involvement in standard-setting by being able to give their opinion during the discussion of projects and to have the characteristics of their products or services considered . Standards help organizations become more competitive by capturing best practices from the market. Standards are also a proven tool to support public administration in the area of regulatory simplification, especially in relation to citizens' safety and environmental protection. Translating part of the project's results into a policy document will facilitate large-scale implementation of the project.

Agency: Spanish Association for Standardization (UNE)

Contribution to digitization

Digital Services and Solutions

1. Digital solutions and services offered by the distributor specifically for the digitization of hospitals
   N.A.

2. Features, benefits, and differentiators of these solutions and services.
   N.A.

3. Success stories or projects where these solutions and services have been implemented with positive results
   N.A.

Current Infrastructures

4. Technological and communications infrastructures offered by the entity for the digitization of hospitals
   N.A.
   Characteristics, specifications, and capabilities of these infrastructures.

   N.A.

5. Certifications and quality standards met by these infrastructures
   N.A.

Current applications

6. Computer applications, tools and systems currently used for the digitization of hospitals
   N.A.

7. Brief description of the function and benefits of each application
   N.A.

Benefits of digitization

8. Highlight the expected benefits of digitizing hospitals, such as improved service quality, process optimization, data security and confidentiality, etc.
   N.A.

Improvements to developing applications, infrastructures, etc

9. Indicate the improvements in applications, infrastructures, and technologies being developed, briefly describing the benefits or improvement expected from this new development.
   The POL Network Design Guide for Smart Hospitals will be transformed into a UNE Specification with the following advantages:

   - Improves the quality of the document with input from industry experts.
   - It facilitates market adoption of the proposed solution due to the recognition of the regulatory documents.
   - It is the first step for government use in public procurement.

4. POL Network Perspectives for Smart Hospitals

4.1. Next-Generation Optical Networking Perspective

The ITU and the IEEE have jointly developed a number of PON standards since the 1990s, mostly in a coordinated manner in terms of transmission rate and wavelength occupancy plan. These standards include APON, BPON, GPON, XG-PON, NG-PON2, XGS-PON and 50-GPON, each of which provides advancements in speed and functionality. These standards have revolutionized the capabilities of fiber optic networks, enabling faster and more efficient data transmission for telecommunications providers around the world. In addition, IEEE introduced EPON and its successor 10G-EPON, which provide alternative standards for Ethernet-based communication in PONs, further expanding the options available for high-speed connectivity solutions.

In the case of Europe and Asia, the regulations adopted have traditionally been those developed by the ITU-T, since it has always offered the most services (e.g. GPON provides data, telephony, and CATV over the same fiber). It has defined the systems and protocols to be developed and implemented in the equipment in more detail.

Motivated by the growing demand for broadband speed, the ITU-T began a project in 2018 to develop PON standards with speeds higher than those previously seen in GPON or XG(S)-PON. This project called Higher Speed PON (HSP) is expected to meet future demands, initially starting in 2018. HSP has initially addressed the use of line rates of up to 50 Gbit/s. The ITU-T recommendation associated with this standard is G.9804 series (released before 2023) and its development has also focused on ensuring the coexistence of this standard with the previous ones. This facilitates the re-use of already deployed optical infrastructure and simplifies FTTx network upgrade processes for service providers, fashionable that can adapt to the growth in demand for services and bandwidth without leading to large investments or interventions that mostly affect customers.[12]

From the system capacity perspective, assuming split ratios close to 1:64, service concurrency of 50%, and payload ratios close to 80%, with a nominal line of 50 Gbit/s, it is possible to provide an average access capacity of 1.25 Gbit/s simultaneously for up to 64 ONTs. This capacity meets the high bandwidth requirements of new services such as virtual or augmented reality that are becoming more popular in the residential market.[13]

In this case, the ITU-T differentiates between three subtypes within the HSP:

- 50G TDM PON. A pair of channels with one wavelength, using TDM/TDMA. The main case covered by the 50G-PON standard
- 50G TWDM PON. An option that will allow multiple wavelength pairs multiplexed on the same fiber, enabling the coexistence of GPON, XG(S)-PON, and 50G-PON triple modes.

The ITU recommendation includes three combinations of transmission rates for the 50G-PON standard:

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[12] ITU-T Recommendation G.9804.3 '50-Gigabit-capable passive optical networks (50G-PON): Physical media dependent (PMD) layer specification'

[13] Dezhi Zhang, Dekun Liu, Xuming Wu and Derek Nesset. Progress of ITU-T higher speed passive optical network (50G-PON) standardization. Journal of Optical Communications and Networking Vol. 12, No 10. October 2020

- Downstream 50Gbit/s and upstream 12.5Gbit/s.
- Downstream 50Gbit/s and upstream 25Gbit/s.
- Downstream 50Gbit/s and upstream 50Gbit/s.

4.1.1. Wavelength Plan

- The ITU-T proposes a solution in the optical spectrum that will facilitate the coexistence between this standard and the previous ones. A band between 1340nm and 1344nm is defined for the downstream channel, while the upstream channel introduces a new wavelength range of 1284nm to 1288nm for coexistence with GPON and XG(S)-PON.

Parameter	TECHNOLOGY		
	GPON	XG(S)-PON	50G-PON
Upstream Rate (Gbit/s)	1.25	2.5-10	12.5-25-50
Download Rate (Gbit/s)	2.5	10	50
Split ratio	1:128	1:128	1:128
Upstream wavelength (nm)	1290-1330	1260-1280	1284-1288
Downstream wavelength (nm)	1480-1500	1575-1580	1340-1344
Maximum attenuation (dB)	35	35	35

Table. Comparison between the different technologies with 50G-PON.4-1

4.1.2. Evolution and Upgrade of PON Technologies

As shown in the wavelength plan, it is important to consider a migration from GPON and XG(S)-PON to 50G-PON. In this regard, there are two main strategies to follow: multi-PON modules (MPMs), aimed at supporting both 50G-PON and any legacy standard; and the coexistence element (CEx), a wavelength multiplexing/demultiplexing filter that needs to be placed in front of the OLTs just before entering the ODN.

Thus, the use of MPM can offer some technical and cost improvements over the use of CEx for large-scale deployment. First, the MPM can help save space and power consumption as well as simplify deployment and engineering work by relying on easily replaceable modules or boards. It would be possible, for example, to replace a module dedicated to GPON or XG(S)PON with a module dedicated to 50G-PON, using the same slot in the rack and being able to. These replacements can mean short outage times for customers or even affect no more than the customers associated with the slot being replaced.

If pre-installed CExs are used in the first deployment, it can be relatively easy to replace them with updated versions that support the use of new standards. but aggregation work can be more complex than MPM if it does not exist in the network prior to the need for coexistence. The use of MPM has now grown in acceptance among operators worldwide and is often the most widely used way to upgrade GPON networks to XG(S)PON networks. Therefore, migration to 50G-PON would be the preferred migration strategy.

Although it is already commercially available, as some manufacturers (e.g. Huawei) already announced its availability in early 2023, 50G-PON is still in the process of being adopted. In fact, the most optimistic prediction is that it will be adopted as the standard for most deployments by 2027-2028. Thus, it is considered mature enough to be used, and now it can only be expected to be gradually adopted by operators and owners of communications infrastructure.[14]

From here, the expected evolution in the near term is to move towards 50G TWDM PON; in line with the (rarely used) NG-PON2 standard. NG-PON2 uses WDM with multiple 10G wavelengths for a symmetrical 40Gbit/s service in both upstream and downstream directions, this allows the three services to co-exist in the same PON. With increasing speed demands annually, XG-PON, XGS-PON, and NG-PON2 offer a particularly advantageous upgrade path in large commercial or multi-user customer environments, as well as within 5G wireless networks. However, it needs multiplexers/demultiplexers and wavelength filters to efficiently (and cheaply) perform the necessary wavelength multiplexing. For this reason, NG-PON2 has not been widely deployed, as it requires adaptations throughout the ODN. However, to explore the 50G TWDM PON, the ITU has created the VHSPON group, which plans to define the technology capable of reaching speeds of 200 Gbit/s, using 4 different wavelengths. where a 50G signal would be mounted on each of them. However, there is still a long way to go as it is unclear which device technology(s) is most viable for this. These include a potential coherent detection to tune transceiver equipment and avoid the use of filters, but the way forward is not yet clear.

4.2. Evolution of use cases for F5G/F5G-A fixed technologies

A fifth-generation fixed network (F5G) is the generation fixed network first proposed by the European Telecommunications Standards Institute (ETSI) and widely accepted by the industry since June 2019. At the end of 2019, ETSI approved the start of the F5G project and defined fixed network generations. Many operators (such as Telefonica, Telecom Italia, Orange, China Telecom), equipment suppliers (such as Huawei, FiberHome, and CommScope) and research institutes (such as CTTC, CAICT and British Standards Institution) are involved in the development of F5G.

[14] https://www.telecomreview.com/articles/reports-and-coverage/7013-the-rise-of-50g-pon-delivering-enhanced-fiber-performance

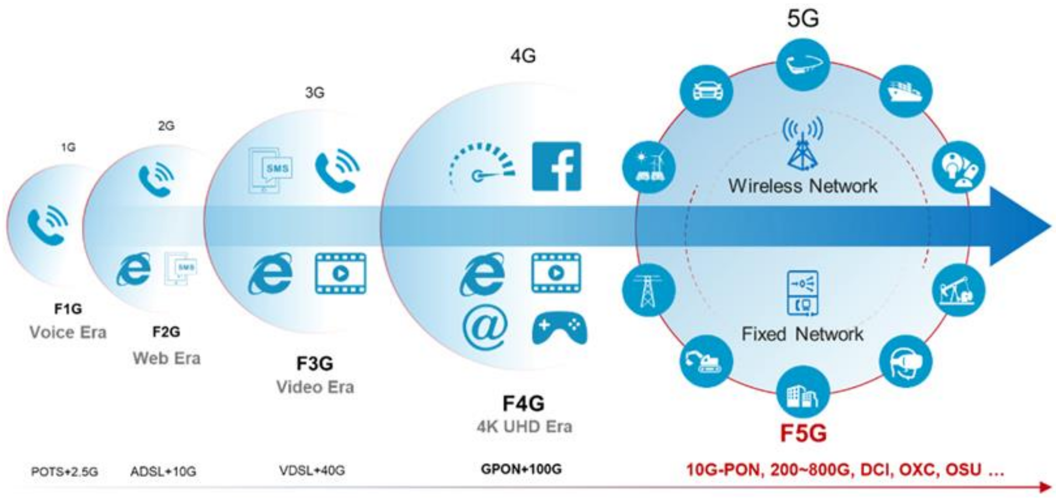


Figure 4-1. Generations of Fixed Network Technologies and Mobile Communications Technologies

F5G provides eFBB, FFC, and GRE. Its typical technologies include 10G, PON, and Wi-Fi 6. An intelligent hospital POL network is based on F5G technology and implements all-optical bearings to interconnect hospital campuses.

In November 2023, ETSI published the F5G Advanced Generation Definition in its Fifth Generation Fixed Network (F5G) report; F5G Advanced Generation Definition, promoting the evolution of F5G. The scope of the advanced F5G system can be described in terms of six dimensions (Figure 4-2), three of which are direct enhancements to the existing dimensions of the F5G project (faster eFBB and GRE, and broader FFC). The remaining new dimensions include greener, smarter, and more conscious networks. In addition, network reliability is a fundamental principle that should not be neglected.**¡Error! No se encuentra el origen de la referencia.**

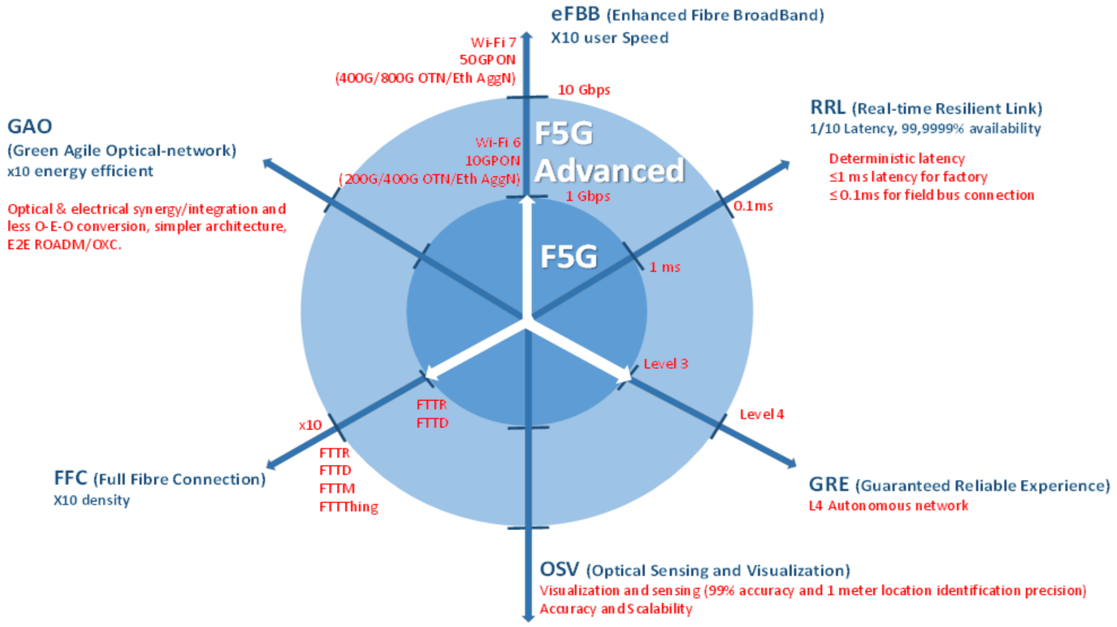


Figure 4-2 F5G Advanceds Dimensions

In 2021, the Fixed 5G (F5G) initiative was created in parallel with the efforts and work of FSAN, ITU, and IEEE to define access technologies and standardize them. It is an ISG (industry study group) of ETSI, which includes Huawei (presidency), CTTC, Meditecs, UNE, and VICOMTECH among the members of this project. F5G studies and develops the generations of the fixed network, promoting the evolution towards a "fiber everywhere" ecosystem that enables new and improved services that leverage, within a framework of growing network capabilities, better performance, intelligent E2E management, network security and increased energy efficiency. This ISG aims to work as a center for the development of standardization of fiber-based networks from an E2E perspective. identifying key use cases and requirements and interacting with all relevant standardization organizations and industry stakeholders to produce new standards when necessary, or improvements to existing standards that may be necessary to meet the identified use cases.[15]

Compared to previous generations such as F4G, the current F5G network technology has improved not only network performance but also energy efficiency by extending fiber everywhere and replacing traditional copper networks. With the overall common goal of reducing carbon emissions and achieving carbon neutrality, it is necessary to promote further advances in F5G network technology to meet the upcoming green transition and low-carbon trends, for example, achieving lower power per bit. At the same time, the low-carbon transformation of several energy-intensive industries can be supported by further improving F5G network technology to provide a smarter grid infrastructure to meet these needs.

Therefore, its objectives include the development and demonstration of different use cases aimed at reinforcing three axes:

- Networks: speed and capacity, coverage (connectivity), responsiveness (latency), and density.
- Service: Reliability, availability and security.

[15] https://www.etsi.org/committee/1696-f5g

- Management: Operational Efficiency, Energy Efficiency, Spectrum Efficiency.

F5G has defined some 14 use cases, in which the use of PON technologies for all types of applications takes into account different dimensions to be covered: enhanced Fixed Broadband (eFBB), real-time resiliency links (Real Time Resilience Link (RRL), Guaranteed Reliable Experience (GRE), Optical Sensing and Visualization (OSV), Full-Fibre Connection (Full-Fibre Connection)) and Green Agile Optical Network (GAO).

It should be noted that among the use cases of F5G, a passive optical local area network (passive optical LAN) based on fiber optic technology has been defined. Although it is also based on the use of PON technology, this case offers examples (hotels, stadiums, holiday resorts, road infrastructure, shopping malls) with very different requirements than smart hospitals.

By the end of 2023, this same think tank has defined what is known as F5G-A (Advanced) to support the next generation of emerging digital services, such as digital twins and virtual worlds. with the aim of further accelerating the popularization of fibre services and meeting citizens' needs for higher quality and personalised services. These emerging digital services impose stricter requirements on communication network technologies.

At the same time, scientific, technological and industrial developments are accelerating worldwide. Digital development has become an important growth engine for the global economy. Industrial digitalization has promoted the transformation of production methods, leading to smarter and higher-quality infrastructures.

Thus, the F5G-A leverages fiber optic network technologies to benefit multiple segments, such as residential applications, enterprise applications, internal network issues, such as network optimizations, in addition to the use of F5G-A for mobile infrastructure and service convergence, and finally use cases aimed at vertical industries. In other words, it is no longer based on the mere use of PON technologies in different contexts but goes a step further and defines use cases that also extend to different network segments.

In the fourth quarter of 2024, new use cases have been defined for F5G-A, including passive local area networks for the healthcare environment, largely contributed by this white paper.

5. Conclusions and recommendations

Although digitalization is a global trend in all economic sectors, the health sector is one of the sectors that is still in the early stages of digitalizing its processes. In this context, the deployment of POL networks in smart hospitals represents a fundamental step towards the digital transformation of the healthcare sector, providing reliable, high-capacity, low-latency connectivity, which is indispensable for the integration of advanced technologies such as AI. the IoT or VR/RA. These technologies optimize diagnoses, treatments, and the overall patient experience. The scalable and interoperable design of POL networks supports a variety of medical and administrative devices, ensuring efficient data flow between key areas of the hospital. It also streamlines the network architecture and reduces deployment times because it is based on PON technology.

In 2023, Spain had 387 public hospitals and 418 private hospitals. At present, many hospital users are not fully familiar with the hospital POL infrastructure. Therefore, this Intelligent Hospitals POL Network Applications Industry White Paper summarizes the requirements and application experience of POL. The main points addressed include the following:

- **Operational efficiency and sustainability. POL networks can significantly reduce energy consumption and operating costs due to their simplified design, reduced material usage and long service life.**
- **Technological convergence. These networks integrate multiple elements into a single infrastructure, facilitating management, improving interoperability, and enabling a more agile response to the demands of smart hospitals.**
- **Improving the patient and health professional experience. POL networks power advanced applications such as telemedicine, home hospitalization, and high-quality videoconferencing by ensuring high-speed connectivity and low latency. This can be useful not only in the basic care processes but also in the training processes of new health professionals.**
- **Security. The POL infrastructure ensures high levels of data protection and security necessary to comply with strict privacy regulations.**
- **Innovation and responsiveness. With its flexibility and scalability, POL networks are positioned as the ideal technology base to support innovations such as AI, massive data analysis, and advances in precision medicine, among many other aspects.**

It is important to emphasize that it is essential to foster cooperation between healthcare, technology and regulatory actors to accelerate digitalization and ensure efficient deployment of these infrastructures. It is therefore suggested that POL should be piloted in the different cases of use in public NHS hospitals.

Finally, this White Paper proposes to elevate the POL Network Design Guide for Smart Hospitals to a use case within ETSI and the Spanish Association for Standardization (UNE) for conversion into a UNE Specification to ensure widespread adoption and alignment with international standards, promoting its implementation in public and private projects. This conversion will improve the quality of the document through expert input, facilitate market adoption due to the recognition of normative documents, and serve as a basis for government procurement use (see Guide to the Use of Technical Standards in Public Procurement In addition, the UNE specification will be promoted as a European standard through UNE, the Spanish member of CEN/CENELEC/ETSI.

6. Glossary

- **AP: Access Point**
- **CATV: community antenna television**
- **CCTV - Closed Circuit Television**
- **CT: computed tomography**
- **DR - Digital X-ray**
- **eFBB - Enhanced Fixed Broadband**
- **ELV: Extra Low Voltage**
- **eMDI: Enhanced Media Delivery Rate**
- **EMR: electronic medical record**
- **FFC: Full Fiber Connection**
- **FTTH fiber to the home**
- **GPON: Gigabit-compliant passive optical network**
- **GRE: Guaranteed reliable experience**
- **HA - High Availability**
- **HIS: Hospital Information System**
- **HRP: Hospital Resource Planning System**
- **IP-PBX: IP PBX**
- **MRI: Magnetic Resonance Imaging**
- **LAN: local area network**
- **LIS: laboratory information system**
- **NE: NE**
- **NMS: network management system**
- **ODN: Optical Distribution Network**
- **OLT: optical line terminal**
- **ONU: optical network unit**
- **OTN: Optical Transport Network**
- **PACS: image archiving and communication systems**
- **PET: Positron Emission Computed Tomography**
- **POL - Passive Optical LAN**
- **PON - Passive Optical Network**
- **POTS - Plain Old Telephone Service**
- **SPECT: single photon emission computed tomography**
- **VLE: Vertical Line Enclosures**
- **VR - Virtual Reality**
- **XGS-PON: 10 gigabit symmetric passive optical network**
- **ZTP: Contactless Provisioning**

Attachments

Annex I. Introduction to the POL Network for Smart Hospitals

AI1. What is a Passive Optical Local Area Network (POL)?

Local Area Networks (LANs) have been widely deployed in different environments such as campuses, buildings, hotels, schools, hospitals, stadiums, and shopping malls, among others, to provide connectivity to end users and transport digital business data in all directions. This connection can be either wireless over Wi-Fi® or wired over Ethernet. LAN backhauling traditionally uses Layer 2 switches, Layer 3 routers, and media connected using copper Ethernet cable, such as CAT5 cable.

There are some limitations to this implementation approach. For one thing, these types of deployments are typically designed in a star topology with the switch/router in the center, so point-to-point cable needs to be deployed from the switch to each of the end devices and/or wireless access points. On the other hand, emerging needs are not met, including the complexity of cable deployment, the bottleneck to upgrade the data transmission rate due to the copper medium, and high-power consumption.

In this context, Passive Optical LAN (POL) based on ETSI GS 013 V1.1.1 (2023-04) - Fifth Generation Fixed Network; Technology Landscape Release 2 is a solution based on Passive Optical Network (PON) technology for LAN deployment, designed to replace traditional copper-based deployments. This change is due to the many advantages optical fiber offers over copper. One of the most notable benefits is the durability of the fiber, which provides a significantly longer service life, reducing the need for frequent upgrades and maintenance. In addition, fiber optic cable has a much smaller diameter compared to copper Ethernet cable, which makes it easier to install and reduces the space required in ducting. Another key point is the lower transmission loss offered by fiber, allowing greater distances to be covered without the need for amplifiers or repeaters, thus improving the overall efficiency of the system. In addition, electromagnetic emissions are much lower in the optical fiber, which helps to minimize interference and improve communications security. The use of fewer active equipment, such as switches and routers, and the low power consumption that characterizes PONs not only reduce operating costs, but also make PONs more energy sustainable. This type of network is specially designed for high-capacity scenarios such as enterprise, public administration, education, health, transportation, and large commercial complexes.

Although constantly shifting toward higher performance, PON is a proven technology in access networks for FTTH fiber-to-the-home scenarios that represents a paradigm shift from the LAN by implementing a tree topology with a point-to-multipoint deployment. In this way, a single fiber starting from the exchange is split in a timely manner by including fiber splitters until reaching the end devices. This type of deployment is advantageous for the deployment of POL, although it will need to be adapted according to the characteristics of the offered services. Today, the most widespread technology in PONs is XGS-PON, which has gained popularity due to its ability to meet the increasing bandwidth demands in various applications. XGS-PON is a state-of-the-art PON system that offers symmetrical transmission rates, i.e. 10 Gbit/s in both upstream and downstream directions. Recently, the latest technology of POL is 50GPON, common rated transmission rate of 50 Gbit/s in both upstream and downstream directions.

A POL network mainly uses GPON and XGS-PON/50G PON technologies. Table 0-0-1 lists the technical specifications of these technologies. It should be noted that these technologies are designed for easy upgrade and switching with almost no service interruption. Thus, the wavelength plan (i.e. channel allocation in the optical spectrum) proposed for each of them is designed to allow GPON equipment to coexist with XGS-PON equipment.

Table 0 GPON/XGS-PON/50GPON Technical Specifications-0-1

Technical Specifications	GPON	XGS-PON	XGS&G Combo PON	50G&XGS Combo PON
Line Speed	Upstream flow: 1.25 Gbit/s	Upstream flow: 9.95 Gbit/s	Upstream flow: 9.95 Gbit/s • 1.25 Gbit/s	Upstream flow: 50 Gbit/s • 9.95 Gbit/s
	Downstream: 2.5 Gbit/s	Downstream: 9.95 Gbit/s	Downstream: 9.95 Gbit/s • 2.5 Gbit/s	Downstream: 50 Gbit/s·9.95 Gbit/s
Wavelength	Upstream flow: 1290 to 1330 nm	Upstream flow: 1260 to 1280 nm	Upstream flow: 1260nm to 1280nm 1290nm to 1330nm	Upstream flow: 1340nm to 1344nm 1575nm to 1580nm
	Descending: 1480-1550 nm	Descending: 1575-1580 nm	Descending: 1575nm to 1580nm 1480nm to 1550nm	Descending: 1340nm to 1344nm 1575nm to 1580nm
Optical Power Budget (dB)	Class B+: 28 Class C+: 32 Class C++: 35	N1:29 N2:31 E1:33	Class B+: 28 Class C+: 32 Class D: 35	Class B+: 28 Class C+: 32 Class D: 35

Compared with traditional LANs, a POL network is an all-optical network that is innovative in architecture and transmission medium. Table 0-0-2 provides a detailed comparison between the Ethernet-based LAN architecture and the POL architecture, highlighting the network architecture, technology, and power required for maintenance.

Table 0-0-2. Architecture comparison between an Ethernet-based LAN and a POL

Technical Solution	Ethernet-based LAN (Copper)	POL Network (Optical Fiber)

Network Architecture	Three-layer network	Two-layer network
Technology	Point-to-Point (P2P)	Point-to-Multipoint (P2MP) Technology
Active/Passive Extra Low Voltage Room (ELV)	Active, with power supply	Passive, no power supply Dividers installed in floor ELV rooms
Transmission media	Copper cable	Fiber optics
Transmission Capacity	Generally, up to 10 Gbit/s	Up to 10 Gbit/s (XGS-PON) or higher
Maximum Transmission Distance	Limited (- 100 meters per segment)	Longer distance (up to 20 km)
Number of active computers	More equipment (switches, routers, etc.).	Fewer active computers
Energy consumption	High due to the number of active computers	Low, fewer active equipment, and less cooling
Physical Space	Requires more space for cabling and equipment	Smaller footprint due to thinner fiber optic cable
Installation Cost	Moderate to Ato (plus equipment and cabling)	Initially higher, but with less long-term maintenance
Maintenance	Larger, due to more points of failure and active equipment	Less, fewer points of failure, and less complexity
Scalability	Less scalable due to copper limitation	Highly scalable with updates to the terminal equipment
Electromagnetic interference	Susceptible to interference	Immune to electromagnetic interference

AI2. Technical Features

Figure 0-1 shows the architecture of a POL network. Generally, an optical line terminator (OLT) is deployed in the equipment room where core switches reside to terminate PON signals and centrally manage optical network units (ONUs) through PON ports and the optical distribution network (ODN). This ODN, which is between the OLT and ONUs, consists of a passive network consisting of passive optical components, including optical fiber cables and one or more optical splitters.

On the user side, an ONU is deployed to provide multiple ports for connecting to devices such as computers, self-service devices, STBs, cameras, wireless access points, printers, and phones. The ONU converts the signals of such devices into PON signals for transmission to the OLT through the upstream PON ports and the ODN. The OLT processes and forwards the received PON signals. The OLT and ONUs are connected through the intermediate passive ODN for communication.

Compared to traditional LANs. The POL network is an all-optical network that is innovative in terms of system architecture and transmission medium.

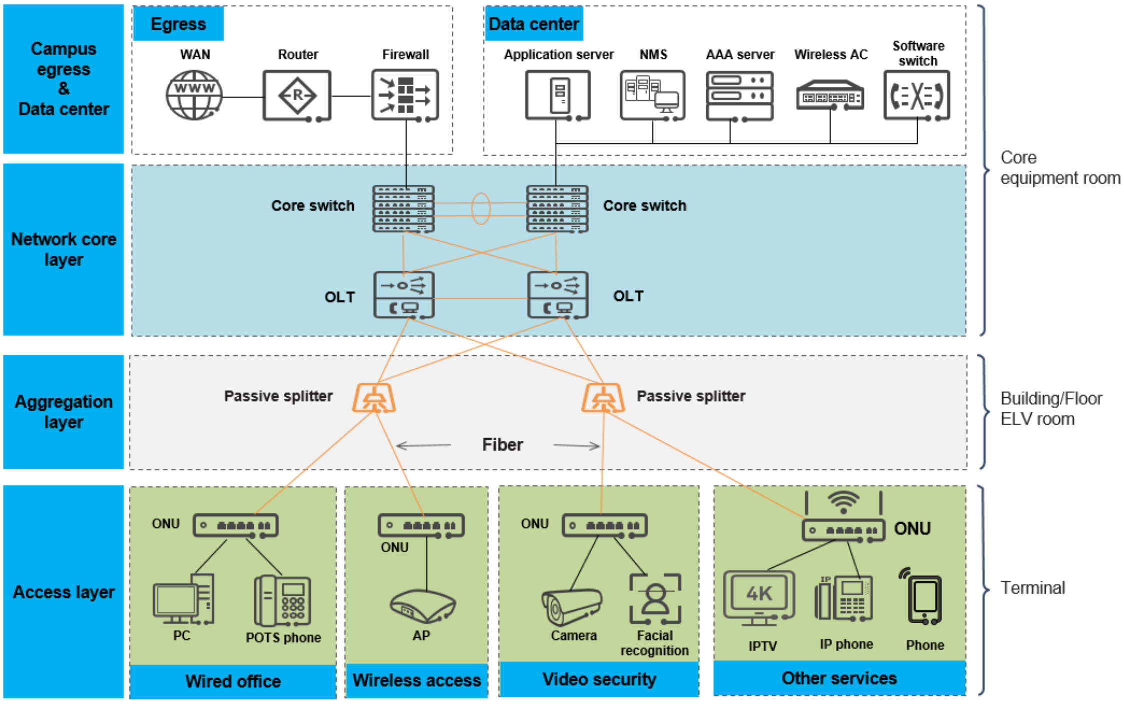


Figure 0-1. Hospital POL Network Architecture

AI3. Optical Fiber Performance

A POL network uses optical fibers to replace network cables as the transmission medium and extends the optical fibers closer to the end devices. The main advantages of using optical fiber are as follows:

- Energy saving and environmentally friendly. Copper mining and smelting consumes a large amount of natural resources and energy, and generates higher emissions than the quartz of which optical fibers are made.
- Higher bandwidth. A POL network transmits data through optical signals between OLTs and ONUs that are connected through an ODN. The optical fibers of the ODN can provide a bandwidth of several tens of THz, which in certain environments supports capacities of several Tbit/s or even Pbit/s. This is an order of magnitude increase over the bandwidth of traditional CAT5e or CAT6A unshielded network cables.
- Longer transmission distance. Optical fibers are characterized by low attenuation and are well suited for long-distance communications with high capacity. In the case of the POL network, the proposed technologies support a transmission distance of up to 40 km compared to hundreds of meters of cable networks.
- Small size and light. The weight of a single-mode optical fiber is less than 8.4 g/m compared to 49 g/m. This is a major advantage in the dimensioning and load bearing capacity of existing cable trays over traditional cabling upgrade alternatives. Figure 0-2 shows a comparison of weight and transmission performance between different network cables and fibers.

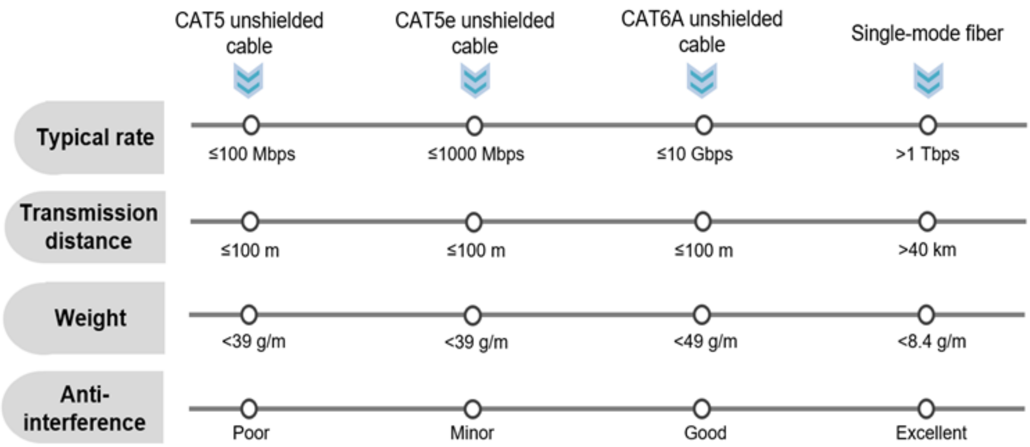


Figure 0-2. Transmission Weight and Performance Comparison Between Network Cables and Optical Fibers

AI4. Simplified network architecture

A POL network has a two-layer architecture (OLT and ONU) eliminating the aggregation layer of a traditional network (Figure 0-3). In addition, a POL network uses passive optical splitters to replace the active aggregation devices in order to optimize the architecture. Figure 0-3. Network architecture of a POL network with fewer active equipment rooms

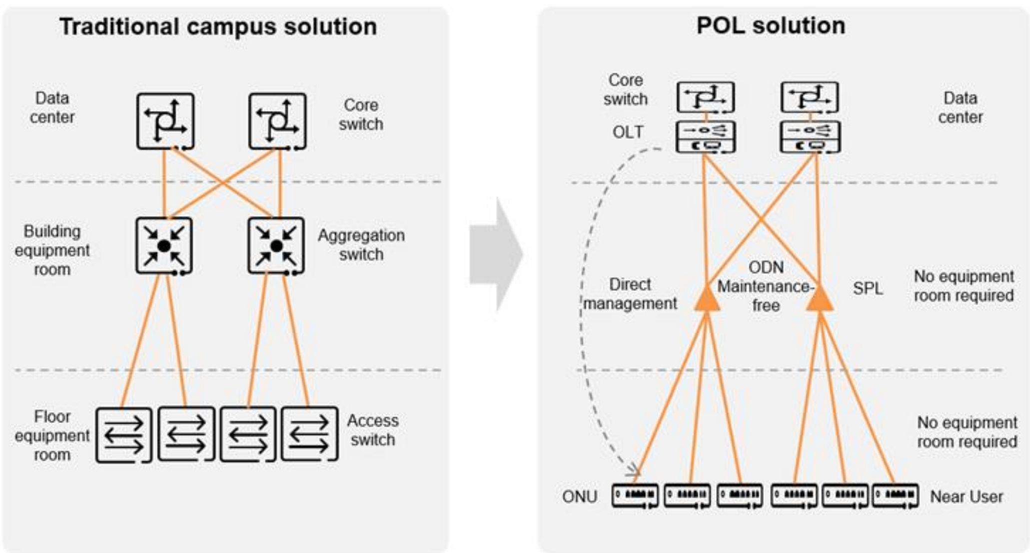


Figure 0-3. Network architecture of a POL network with fewer active equipment rooms

The following are the advantages of a POL network over a traditional one. First, the active aggregation switches used by a traditional Ethernet network are removed. The POL network realizes network aggregation through passive optical splitters over optical fibers, significantly reducing power consumption and thus carbon emissions. In addition, the reduction in the number of switching/forwarding nodes reduces congestion and latency, improving transmission quality and helping service systems exchange data efficiently.

Second, space is reduced in the VLE (Vertical Line Enclosures) and ELV (Extra Low Voltage) rooms.

Passive optical splitters do not require power supply or cooling devices, this significantly reduces the surface area allocated to the equipment and optimizes the use of space.

Finally, the optical modules of an all-optical Ethernet are also reduced by about half. On the one hand, an all-optical Ethernet solution uses all-optical aggregation switches to aggregate data in a star architecture with point-to-point (P2P) links. Therefore, the number of optical modules configured for all-optical aggregation switches must be equal to the number of optical modules configured for access switches. On the other hand, a POL network uses the point-to-multipoint tree topology (P2MP) aggregation technology. If a 1:8 splitter is used, one PON optical module of the OLT can be connected to the PON optical modules of eight ONUs.

As shown in Figure 0-4, you need to configure 16 optical modules for eight access switches and 16 optical modules for the two all-optical aggregation switches in all-optical Ethernet networks, for a total of 32 optical modules. In the POL solution, eight ONUs with 16 optical modules must be externally configured. (Most ONUs have built-in optical modules. Passive splitters do not require optical modules, only two optical modules need to be configured on the two OLTs, resulting in a total of 18 optical modules. Thus, in this particular case there is a reduction of approximately 44% of optical modules.

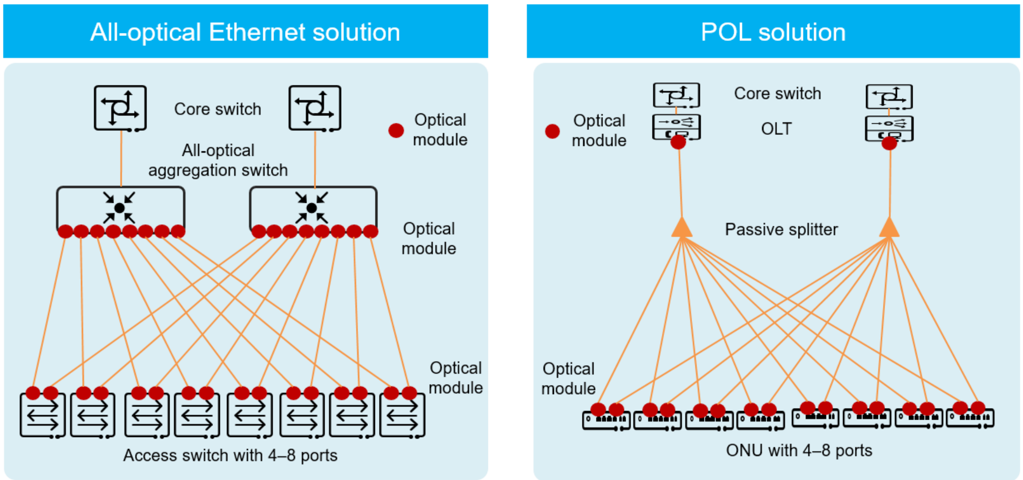


Figure 0-4.Saving the number of optical modules in a POL network

AI5. Multiservice Orientation

A POL network allows a single optical fiber to carry multiple services, including multiple services in traditional Ethernet networks, traditional POTS telephony services, and community antenna television, simplifying the final network structure. These services can be extended to IoT applications, providing a robust network for all types of services. The following describes some interfaces of a POL network for carrying services (Figure 0-5).

- Support Wi-Fi 6 access points to provide high-speed Wi-Fi access.
- Ethernet ports to support features such as desktop cloud office and dial-up Internet Protocol (IP) access.
- High-speed Internet access.

- Support for POTS service by providing access to traditional phones.
- IPTV service with 1080p, 4K, or 8K high-definition (HD) videos.
- CCTV service with access to multiple security cameras.
- OTN ports to support multi-wavelength fiber interconnection between devices.
- Access various IoT sensing devices, such as smart building sensors, through the IoT gateway to provide services such as access control. Access to various medical equipment and data center connections, including CT, DR, and MRI devices.

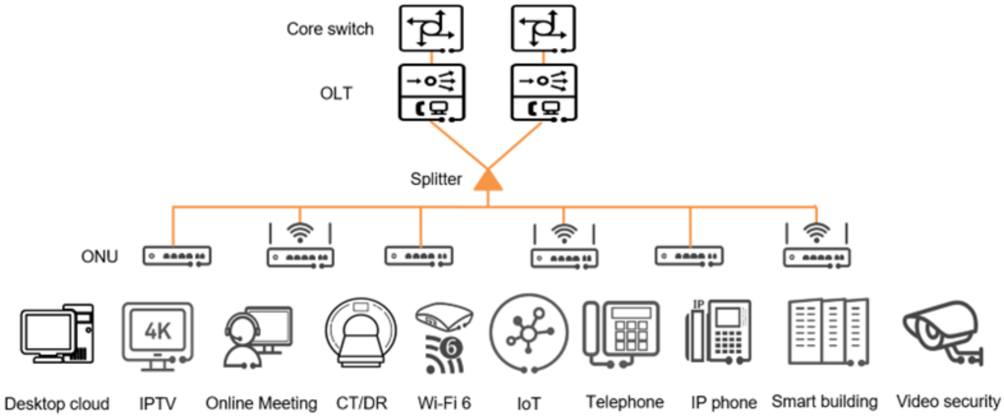


Figure 0-5. Adapting a POL Network for Multiservice Use

A POL network supports the transmission of multiple services with better security because it uses the PON technology to isolate services with different service level agreements (SLAs) by timeslots or wavelengths. It is also capable of encrypting data on fiber lines, so the OLT manages ONUs in a unified manner and ONUs use unique encryption keys, improving the security of data transmission through optical fibers.

AI6. Progressive Evolution

A POL network is designed to be highly scalable and adaptable to future needs. First, a POL network uses optical fibers that support smooth bandwidth evolution. Optical fibers are immune to interference and corrosion and have an average lifespan of about 30 years after deployment. In addition, they can offer a width of several tens of THz capable of supporting very high-speed links. Therefore, there is no need to replace or upgrade optical fibers when you want to upgrade the network to increase its transmission speed. This is an advantage over the need to upgrade copper cables to support a higher capacity due to their lower bandwidth compared to optical fiber.

Second, the capability of an all-optical Ethernet involves replacing aggregation switches in ELV rooms and modifying related configurations, resulting in a complex, costly, and time-consuming process. However, a POL network does not need to change the ODN during bandwidth upgrade, but simply upgrade the OLTs and ONUs, minimizing the required workload and reducing service disruption times.

Additionally, a POL network can implement smooth evolution of capacity and services by flexibly adding wavelengths. In general, PON standards are defined so that they do not interfere with each other so that existing services are not affected when capacity is upgraded and/or new services are created. As shown in Figure 06, you can deploy GPON (wavelength 1) and XGS-PON (symmetric 10G PON, wavelength 2) in a POL network to support the desktop cloud and connect to other types of devices. In the future, you can consider replacing GPON with 50G-PON (wavelength 3) to include the support of Wi-Fi 7 and even 200G PON (wavelength 4) to support high-bandwidth emerging services. as 360° 24K RV.Figure 0-6. Smooth evolution of the bandwidth of a POL network by adding wavelengths.

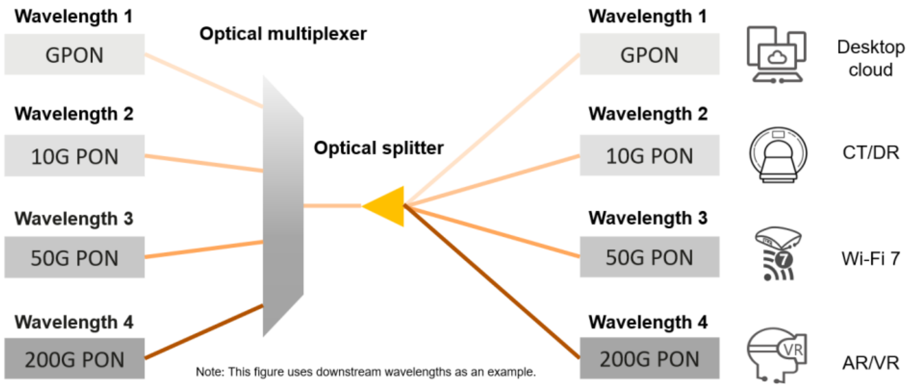


Figure 0-6. Smooth evolution of the bandwidth of a POL network by adding wavelengths.

Finally, it is important to note that both approaches, the traditional Ethernet-based LAN and the POL network, are not mutually exclusive, but can coexist within the same infrastructure. This allows a gradual transition from a copper-based network to an all-optical architecture, facilitating technology evolution without the need for abrupt or costly migration. In this context, it is possible to adopt a phased strategy for the implementation of the POL network, starting with the least critical segments and gradually moving towards the most sensitive ones. Therefore, the evolution can take place in a sequence beginning with the intranet, the extranet, and finally the organization's safety network. This step-by-step approach not only reduces risk and impact on operations but also optimizes investment by leveraging existing infrastructure while making strategic upgrades to a more modern and efficient network.

Figure 0-7 shows two networks (intranet and extranet) applying the traditional Ethernet solution that wants to evolve into a POL solution in different phases. In the first phase, the extranet remains unchanged and continues to run on the original aggregation and access switches, while the intranet is rebuilt according to a POL network. The extranet (traditional Ethernet) and the intranet (POL) coexist in the same trunk switch group (core). In a second phase, the extranet would also be upgraded to the POL network.Figure0-7. Smooth network reconstruction using the POL solution.

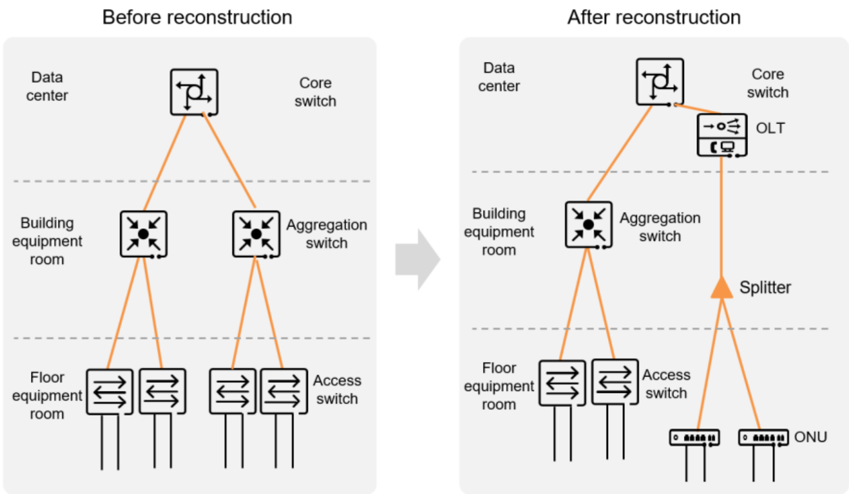


Figure0-7. Smooth network reconstruction using the POL solution.

AI7. Easier operation and maintenance

A POL network provides fast and easy network management. It applies to the P2MP architecture, in which the OLT manages ONUs in a centralized manner to reduce separate management nodes and management and configuration workload. Therefore, you do not need to configure separate management IP addresses for massive ONUs, but the OLT configures a management IP address in a unified manner, and the ONUs are considered as remote functional modules of the OLT. This means that only the OLT needs to be configured during service provisioning and deployment. In contrast, the all-optical Ethernet solution involves configuring up to thousands of separate management nodes for all-optical aggregation switches and access switches (Figure 0-8).Figure 0-8 Centralized Management for POL Network Nodes

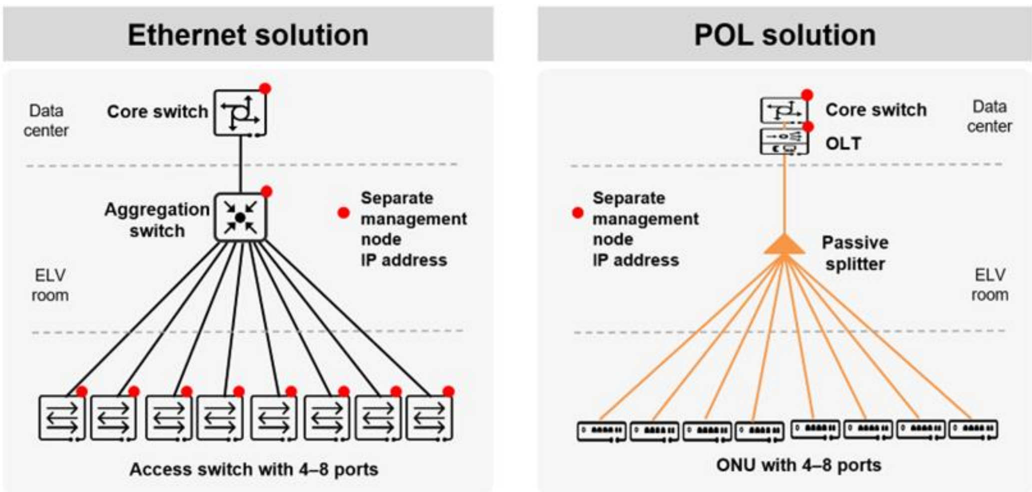


Figure 0-8 Centralized Management for POL Network Nodes

Additionally, a POL network enables ONU Plug&Play and Contactless Provisioning (ZTP) through a network management system (NMS) that allows ONUs to connect and automatically deploy services in minutes. Simplified architecture, passive ODN with few faults, and centralized ONU management have greatly reduced the network O&M workload.

In a POL network, an NMS can be used to manage OLTs and ONUs in a visual manner and perform functions such as user authentication, alarm management, performance management, report management, PON deployment, and PON resource management. An NMS can also implement fiber diagnostics and display information, including the status of optical modules and fibers, as well as fiber failure points. These functions are summarized in Table 002.Table 0-2. Functions of the Network Management System (NMS)

Table 0-2. Functions of the Network Management System (NMS)

System Management Element	Function Description
Security Management	It implements security control on the NMS through user management, operation authorization management (rights-based and domain-based), user login management, and a number of other security policies. It can manage logs generated during user login, user operations, and system run, and supports comprehensive high availability (HA) and database backup solutions.
Topology Management	Displays managed network elements (NEs) and their connections in a topological view, through which users can learn the network structure and monitor the running status of the entire network in real time.
Fault Diagnosis	Provides various network connectivity test methods to diagnose faults in carrier networks.
Performance Management	Identifies network performance deterioration to prevent faults.
Log Management	It records NMS operations and important system events to help detect unauthorized logins and operations and analyze faults in a timely manner.
Software Management	It manages NE data and supports NE software upgrade and downgrade.

Annex II. Pilot project in the reference hospital. Spain

AII1. Definition

The reference hospital has certain latency, bandwidth, and connectivity issues in use cases such as Telemedicine, PACS, or 4K Streaming. Therefore, it is proposed to implement a pilot project limited to a limited number of spaces where the benefits of implementing connectivity based on POL technology can be evaluated in a very non-intrusive way so as not to interfere with the overall operation of the hospital. Thus, it is proposed to evaluate and improve the following processes or use cases:

- Telemedicine, limited to outpatient clinics and framed in a new model of outpatient care for chronic patients.
- A change from the traditional person-centred consultation model tailored to the individual's needs.
    - Direct interaction with various hospital services such as radiology that would allow smoother access to imaging studies
    - Developing Telemedicine and Patient Connectivity
    - Smoother interconnectivity with patient information via Horus
- Live broadcast of events in high definition with 4K quality, the function room is commonly used for online broadcast events where you want to improve the broadcast quality

AII2. Implementation

Some highlights for deploying POL-based connectivity for the above use cases are as follows:

- Estimated 30-year lifecycle without the need for fiber changes when upgrading equipment.
- Efficient solution in terms of space, energy, and overall cost of deployment and operation.
- Multi-service solution with very low latency and high bandwidth features to take on any type of current and future service. It is assumed that data traffic will increase significantly due to new technological developments, such as 3D/4D medical CT, MRI, or Ultrasound imaging; robotic surgical systems (e.g., Da Vinci); increasing use of AI and VR/AR; healthcare professionals, patients, and connected teams; or telemedicine and home patient care.

For the implementation of the use case, specific scenarios have been defined, with a parallel infrastructure deployment, which does not imply any change in the network and operation existing in the spaces involved or in the rest of the services and spaces of the hospital.

AII3. Defined Scenarios, Use Cases, and Connectivity

- **Area 1. Consultation Rooms Chronic Diseases HIV.**
    - Consultation Rooms 1-4 and DIA Consultation
    - Telemedicine, PACS
    - Connection type: PC, IP phone, printer LAN port + local Wifi connection

- **Area 2. Pathological anatomy.**
    - Main office, Scanner room, and Pathologists work room
    - PACS
    - Connection type: PC, IP phone, printer LAN port

- **Area 3. Auditorium.**
    - Control Room
    - Live online 4K video streaming
    - Connection type: PC, IP phone, printer LAN port

The use cases and bandwidth requirements to be discussed in this pilot are as follows:

1. HD Telemedicine: 100 Mbps
2. PACS, Image Access in Query: 500 Mbps
3. PACS, High-Resolution Image Access, Analysis, and Diagnostics: +1Gbps
4. 4K Video Streaming Online: 100 Mbps

Area	Room Description	Use Cases	Requirement for the network device	Total bandwitdh per room
Consultation rooms	4 standard consulting rooms	**Telemedicine** **PACS,TC Image Access** **Wired and wireless connectivity**	Up to 8*Gbe LAN ports with built-in wifi6 antenna	1,2Gbps
	1 high-configuration room		10GE + 4 to 8 Gbe LAN ports with built-in wifi6 antenna	2,2Gbps
Image Analysis Room	Main Query	**1. PACS,TC Imaging Diagnostics** **Wired Connectivity**	10 Ge and up to 8 Gbe LAN ports	2Gbps
	Pathologists' workroom		Up to 8 Gbe LAN ports	1Gbps
	Scanner		Up to 8 Gbe LAN ports	1Gbps
Meeting Room	Auditorium	1. 4k video streaming **Wired Connectivity**	10 Ge and up to 8 Gbe LAN ports	1Gbps

- **Areas or spaces involved**
  Three connectivity areas have been defined as described, corresponding to the following locations in the general plan of the Hospital (Figure 0-9).

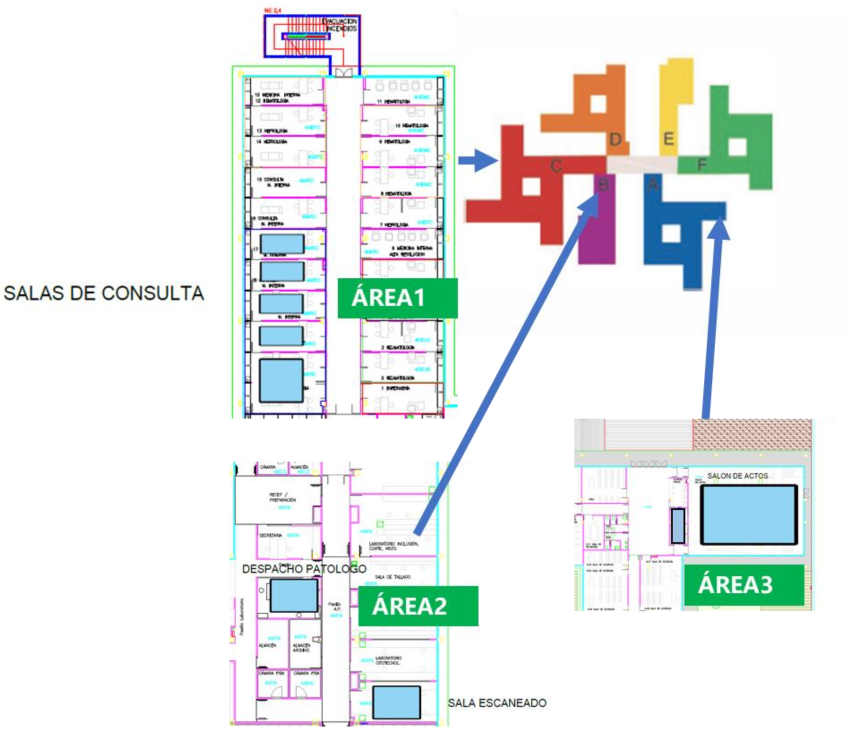
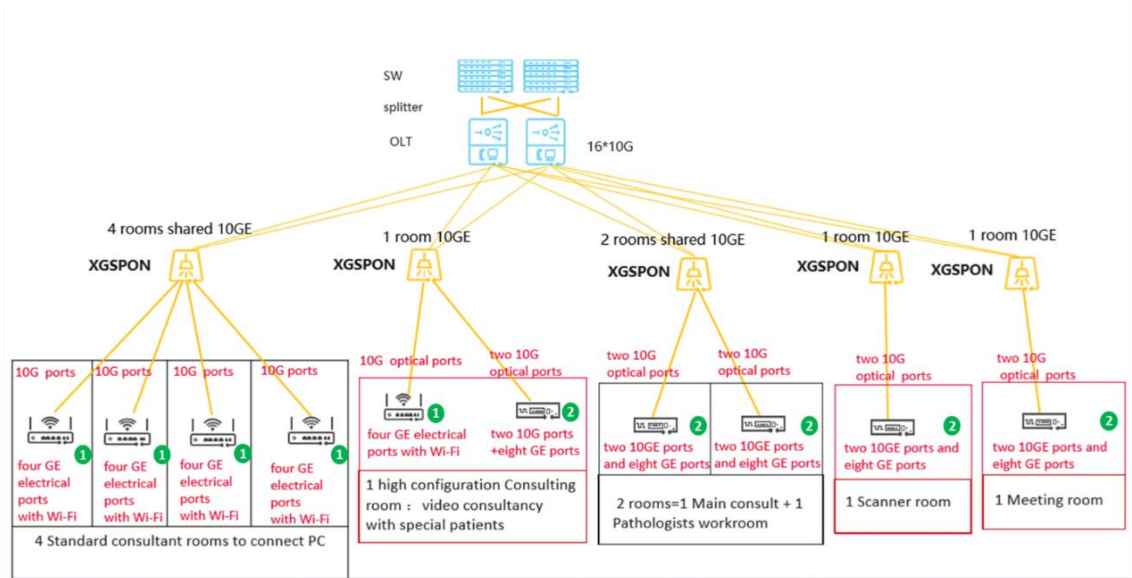


Figure 0 9. Map of the hospital facilities.

AII4. Proposed network architecture

A basic architecture of POL RED in HA high availability configuration is proposed, with two models of space or room (Figure 0-10):

- Standard configuration sharing the XGSPON port of the OLT.
- High Capacity Configuration, dedicated XGSPON port from the OLT.



	WAN Port/Upstream speed	LAN Port/ Downstream speed	Wifi	Wifi Throughtput
1	XGS-PON 10G optical	4*GE electrical ports	2.4 GHz&5 GHz Wi-Fi 6 function	574 Mbps (2.4GHz) 2402 Mbps (5GHz)
2	2*XGSPON 10G optical	2*10GE ports with PoE++ / 4*GE + 4*GE PoE+	/	/

Figure 0 10. Proposed Network Architecture

- **Infrastructure needs for the pilot:**
  - Rack space with at least two rack units to place OLTs with AC power supply in RITI floor -1.
  - Two free optical fiber pairs to communicate with the OLT with the ARUBA CORE Switch located in the CPD room
  - Relaying of optical fiber by vertical skid from floor -1 to the corresponding heights.
  - Location of passive splitter in vertical skid for horizontal access according to network scheme.
  - Relaying of horizontal optical fiber by suspended ceiling from each Splitter to each location or final space defined in the pilot.
  - Optical fiber terminal box and GPON ONU in AC in each end space.

AII5. Conclusions

Trouble spots and new demands

- High bandwidth, low latency, and high availability services
- Slow access to images and difficulty accessing databases during peak hours.
- New requirements for sustainability and energy saving.
- Reduce troubleshooting times and increase overall network availability.

Overall benefits for hospital network operation

The new hospital network based on all-optical POL technology has high bandwidth, low latency, high reliability, and very low power consumption, providing a high-quality network environment suitable for energy efficiency requirements. It is a unified multiservice network, which enables unified, simple, and efficient operation and maintenance management, reducing network downtime and greatly reducing workload.

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Annex III. Main commitments of the PRTR in the area of Digital Health

#	Program Name	Summary Description	Qualitative Indicators	Quantitative Indicators	Target Date	Responsibility	Understanding Milestones and Objectives
284	Health data lake operational	Creating a functioning health data lake for massive data analysis for diagnosis and treatment.	Operational status of the health data lake.	Number of regions/cities involved (at least 17).	Q4 2023	Ministry of Digital Transformation and the Civil Service	Implementation of a health data system available for 17 autonomous regions or cities.
283	Plan to rationalise the consumption of pharmaceuticals and promote sustainability	Implementation of the VALTERMED system and health technology assessment platform.	Coming into operation of the system and evaluation network.	Operationalization of the VALTERMED system.	Q4 2023	Ministry of Health	Operation of the VALTERMED system and creation of a platform for health technology evaluation.
279	Investment plan for high-tech equipment in the National Health System	Renovation and installation of 750 new high-tech equipment in the National Health System.	Detailed list of new equipment installed.	At least 750 new pieces of equipment installed.	Q4 2023	Ministry of Health	Installation of at least 750 new equipment through renovations and new installations across the country.
252	National AI Strategy	Funding at least 7 projects with innovative AI-based solutions to solve specific problems.	Publication of project awards.	Funding of collaborative projects (EUR 10-15 million).	Q1 2026	Ministry of Digital Transformation and the Civil Service	Funding of at least 7 projects in areas such as health, industry, environment, etc. with AI-based solutions.
238	Strengthening connectivity in centres of reference, socio-economic	Improved connectivity in key centers and strategic sectors.	Improved connectivity in key centers and sectors.	At least 16,100 entities with	Q4 2023	Ministry of Digital Transformation and the Public Service,	Enhancing 1-Gigabit connectivity in 16,100 entities, including health, education, and other sectors.

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#	Program Name	Summary Description	Qualitative Indicators	Quantitative Indicators	Target Date	Responsibility	Understanding Milestones and Objectives
	drivers and sectoral digitalisation projects			enhanced connectivity.		Autonomous Communities and Autonomous Cities	
180	Sectoral data spaces to digitise strategic production sectors.	Creating interoperable high-value sector data spaces in strategic sectors.	Create at least 4 sector data spaces.	4 sector data spaces created.	Q2 2026	Ministry of Ecological Transition and Demographic Challenge	Implementation of sector data spaces in sectors such as agri-food, sustainable mobility, health and trade.
165	Specific projects to digitise the central government	Award of projects to support the digitization of the Central Public Administration.	Publication of project awards.	At least EUR 1205 million in awards.	Q4 2023	Various Ministries	Digital transformation in areas such as health, justice, employment, inclusion, social security, migration and other sectors.
163	Specific projects to digitise the central government	Interoperable platforms for the exchange of social security and health data.	Platform Functionality Certificates.	Complete platform operation.	Q3 2023	Ministry of Health	Fully interoperable platforms for data exchange in primary care, hospitalizations, and others.

INDUSTRY WHITE PAPER ON SMART HOSPITALS POL (PASSIVE OPTICAL LAN) NETWORK APPLICATIONS

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